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Volume 4

Department of Energy
FY 2015 Congressional Budget Request

Science

Advanced Research Projects Agency–Energy

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(Discretionary dollars in thousands)

Department of Energy Budget by Appropriation	FY 2013 Current	FY 2014 Enacted	FY 2015 Request	FY 2015 vs. FY 2014 $	FY 2015 vs. FY 2014 %
Energy and Water Development and Related Agencies					
Energy Programs					
Energy Efficiency and Renewable Energy	1,691,757	1,900,641	2,316,749	+416,108	+21.9%
Electricity Delivery and Energy Reliability	129,196	147,242	180,000	+32,758	+22.2%
Nuclear Energy	708,429	888,376	863,386	-24,990	-2.8%
Fossil Energy Programs					
Clean Coal Technology	0	0	-6,600	-6,600	N/A
Fossil Energy Research and Development	498,715	561,931	475,500	-86,431	-15.4%
Naval Petroleum and Oil Shale Reserves	14,129	19,999	19,950	-49	-0.2%
Elk Hills School Lands Fund	0	0	15,580	+15,580	N/A
Strategic Petroleum Reserve	182,625	189,360	205,000	+15,640	+8.3%
Northeast Home Heating Oil Reserve	3,590	8,000	1,600	-6,400	-80.0%
Total, Fossil Energy Programs	***699,059***	***779,290***	***711,030***	***-68,260***	***-8.8%***
Uranium Enrichment D&D Fund	448,231	598,574	530,976	-67,598	-11.3%
Energy Information Administration	99,508	116,999	122,500	+5,501	+4.7%
Non-Defense Environmental Cleanup	223,457	231,741	226,174	-5,567	-2.4%
Science	4,681,195	5,066,372	5,111,155	+44,783	+0.9%
Advanced Research Projects Agency - Energy	250,636	280,000	325,000	+45,000	+16.1%
Departmental Administration	119,195	126,449	129,052	+2,603	+2.1%
Office of Indian Energy Policy and Programs	0	0	16,000	+16,000	N/A
Office of the Inspector General	39,803	42,120	39,868	-2,252	-5.3%
Title 17 - Innovative Technology					
Loan Guarantee Program	0	20,000	7,000	-13,000	-65.0%
Advanced Technology Vehicles Manufacturing Loan Program	5,686	6,000	4,000	-2,000	-33.3%
Total, Energy Programs	***9,096,152***	***10,203,804***	***10,582,890***	***+379,086***	***+3.7%***
Atomic Energy Defense Activities					
National Nuclear Security Administration					
Weapons Activities	6,966,855	7,781,000	8,314,902	+533,902	+6.9%
Defense Nuclear Nonproliferation	2,237,420	1,954,000	1,555,156	-398,844	-20.4%
Naval Reactors	994,118	1,095,000	1,377,100	+282,100	+25.8%
Federal Salaries and Expenses/1	377,457	377,000	410,842	+33,842	+9.0%
Cerro Grande Fire Activities	-61	0	0	0	N/A
Total, National Nuclear Security Administration	***10,575,789***	***11,207,000***	***11,658,000***	***+451,000***	***+4.0%***
Environmental and Other Defense Activities					
Defense Environmental Cleanup	4,627,054	5,000,000	5,327,538	+327,538	+6.6%
Other Defense Activities	760,030	755,000	753,000	-2,000	-0.3%
Defense Nuclear Waste Disposal	-727	0	0	0	N/A
Total, Environmental and Other Defense Activities	***5,386,357***	***5,755,000***	***6,080,538***	***+325,538***	***+5.7%***
Total, Atomic Energy Defense Activities	***15,962,146***	***16,962,000***	***17,738,538***	***+776,538***	***+4.6%***
Power Marketing Administrations					
Southeastern Power Administration	0	0	0	0	N/A
Southwestern Power Administration	11,243	11,892	11,400	-492	-4.1%
Western area Power Administration (CROM)	90,949	95,930	93,372	-2,558	-2.7%
Falcon and Amistad Operating and Maintenance Fund	220	420	228	-192	-45.7%
Colorado River Basins	-23,000	-23,000	-23,000	0	N/A
Transmission Infrastructure Program	0	0	0	0	N/A
Total, Power Marketing Administrations	***79,412***	***85,242***	***82,000***	***-3,242***	***-3.8%***
Federal Energy Regulatory Commission (FERC)	0	0	0	0	N/A
Subtotal, Energy and Water Development and Related Agencies	***25,137,710***	***27,251,046***	***28,403,428***	***+1,152,382***	***+4.2%***
Uranium Enrichment D&D Fund Discretionary Payments	0	0	-463,000	-463,000	N/A
Excess Fees and Recoveries, FERC	-279	-26,236	0	+26,236	+100.0%
Total, Discretionary Funding by Appropriation	**25,137,431**	**27,224,810**	**27,940,428**	**+715,618**	**+2.6%**

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Science
Proposed Appropriation Language

For Department of Energy expenses including the purchase, construction, and acquisition of plant and capital equipment, and other expenses necessary for science activities in carrying out the purposes of the Department of Energy Organization Act (42 U.S.C. 7101 et seq.), including the acquisition or condemnation of any real property or facility or for plant or facility acquisition, construction, or expansion, and purchase of not more than [25] *17* passenger motor vehicles for replacement only, including [one law enforcement vehicle, one ambulance, and one bus, $5,071,000,000] *two buses, $5,111,155,000*, to remain available until expended: *Provided*, That [$185,000,000] *$189,393,000* shall be available until September 30, [2015] *2016*, for program direction[: *Provided further*, That not more than $22,790,000 may be made available for U.S. cash contributions to the International Thermonuclear Experimental Reactor project until its governing Council adopts the recommendations of the Third Biennial International Organization Management Assessment Report: *Provided further*, That the Secretary of Energy may waive this requirement upon submission to the Committees on Appropriations of the House of Representatives and the Senate a determination that the Council is making satisfactory progress towards adoption of such recommendations].

Explanation of Change

Appropriation language updates reflect the funding and replacement passenger motor vehicle levels requested in FY 2015, and does not extend FY 2014 restrictions on ITER funding related to governing Council meetings to be held during FY 2014.

Public Law Authorizations

Science:

- Public Law 95-91, "Department of Energy Organization Act", 1977
- Public Law 102-468, "Energy Policy Act of 1992"
- Public Law 108-153, "21st Century Nanotechnology Research and Development Act 2003"
- Public Law 109-58, "Energy Policy Act of 2005"
- Public Law 110-69, "America COMPETES Act of 2007"
- Public Law 111-358, "America COMPETES Reauthorization Act of 2010"

Nuclear Physics:

- Public Law 101-101, "1990 Energy and Water Development Appropriations Act," establishing the Isotope Production and Distribution Program Fund
- Public Law 103-316, "1995 Energy and Water Development Appropriations Act," amending the Isotope Production and Distribution Program Fund to provide flexibility in pricing without regard to full-cost recovery

Workforce Development for Teachers and Scientists:

- Public Law 101–510, "DOE Science Education Enhancement Act of 1991"
- Public Law 103–382, "The Albert Einstein Distinguished Educator Fellowship Act of 1994"

Science

($K)

FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request
4,681,195	5,066,372	5,066,372	5,111,155

Overview

The Office of Science mission is to deliver the scientific discoveries and major scientific tools that transform our understanding of nature and advance the energy, economic, and national security of the United States. The Office of Science 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 Office of Science 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 Office of Science supports research to probe the most fundamental questions of its disciplines.
- *The 21st Century tools of science*—providing the Nation's researchers with over 30 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 Office of Science has long been a leader of U.S. scientific discovery and innovation. Over the decades, Office of Science 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 2013 enabled by the Office of Science 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 2015 Budget Request

The Office of Science FY 2015 Request is for $5.11 billion, growing by $44.8 million or 0.9% relative to the FY 2014 appropriation. The FY 2015 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 Office of Science user facilities continue to offer capabilities unmatched anywhere in the world; nearly 28,000 researchers from universities, national laboratories, industry, and international partners are expected to use the these facilities in FY 2015. The FY 2015 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 $62.9 million or 13.2% relative to the FY 2014 appropriation. The increase provides support for research and the development of tools underpinning data-intensive science and for research in critical technologies and system integration to accelerate the development of component technologies needed for extreme-scale computing. The FY 2015 Request supports improvements at the two Leadership Computing Facilities to prepare for 75–200 petaflop upgrades at each facility, and more than doubles the production computing capacity at the National Energy Research Scientific Computing Center (NERSC) to address growing demand. Also supports the initiation of a post-doctoral training program for high-end computational science and engineering.

- *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 $94.6 million or 5.5% from the FY 2014 appropriation. The requests continues support for on-going core research, EFRCs, and the Fuels from Sunlight and Batteries and Energy Storage Energy Innovation Hubs. Operations of five synchrotron light sources, five nanoscale research centers, and two neutron scattering centers are supported at optimal levels. The request also provides for the Advanced Photon Source Upgrade, National Synchrotron Light Source II (NSLS-II) Experimental Tools, and Linac Coherent Light Source II projects. Decreases due to the completion of NSLS-II construction in FY 2014 and the transition of the Lujan Center to a safe storage condition in FY 2015 are offset by investments in strategic areas. In particular, funding is requested for a new investment in computational materials sciences for the development of open source community codes for the design of functional materials.
- *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 $18.3 million or 3.0% over the FY 2014 appropriation. Increases support a new climate model development and validation strategy that exploits new software engineering and computational upgrades to facilitate development of higher resolution earth-system models that are compatible with near-term and next-generation computers. The request continues support for core research in Genomic Science and the three DOE BRCs, while funding for Radiological Sciences is decreased. Operations are supported at near-optimal levels for BER's three scientific user facilities, the Joint Genome Institute, the Environmental Molecular Sciences 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 of fusion energy. FES decreases $88.7 million or 17.6% from the FY 2014 appropriation. Funding is provided for the U.S. Contributions to ITER project, including the delivery of major hardware components. The National Spherical Torus Experiment Upgrade (NSTX-U), completed in FY 2014, begins full research operations in FY 2015. Increased funding is provided for DIII-D and NSTX scientific research programs to enable more support for collaborations with additional university and national laboratory scientists and students. The Alcator C-Mod facility resumed operation in FY 2014. It continues operation in FY 2015 during which time a transition plan will be developed for the facility. Support for research in general plasma physics continues, while high energy density laboratory plasmas decreases in FY 2015.
- *High Energy Physics (HEP)* supports research toward understanding 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 decreases by $52.5 million or 6.6% below the FY 2014 appropriation. Investments support full operations of existing HEP facilities and experiments, including the first full year of running with the NOvA detector in the world's most intense neutrino beam. The request supports the planned construction funding profile for the Muon to Electron Conversion Experiment, and new MIEs for the Large Hadron Collider (LHC) ATLAS (A Large Toroidal LHC Apparatus) and Compact Muon Solenoid (CMS) detector upgrades. The FY 2015 request increases to support the second year of fabrication of the Large Synoptic Survey Telescope and investments in accelerator R&D. Research funding decreases in FY 2015 to offset these critical investments.
- *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 can exist in the universe, including those that are no longer found naturally. NP increases $24.4 million or 4.3% relative to the FY 2014 appropriation. The increase supports the construction of Facility for Rare Isotope Beams consistent with the performance baseline profile approved in August 2013. Funding for the 12 GeV Continuous Electron Beam

Accelerator Facility Upgrade decreases as accelerator commissioning is completed in FY 2015 and construction transitions to operations funding. Funding also provides for operations of the Relativistic Heavy Ion Collider for 22 weeks, and for the operations of approximately 37 weeks of beam time at the Argonne Tandem Linac Accelerator System. Core research is held nearly flat with FY 2014.

Basic and Applied R&D Coordination

Coordination between the Department's basic research and applied technology programs is a high priority for the Secretary of Energy. The Department has a responsibility to coordinate its basic and applied research programs to effectively integrate R&D conducted by the science and technology communities (including national laboratories, universities, and private companies) that support the DOE mission. Coordination between the basic and applied programs is enhanced through activities such as joint planning meetings and 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 and Small Business Technology Transfer programs. Co-funding research activities and facilities at the DOE laboratories and funding mechanisms that encourage broad partnerships are additional means to facilitate greater communication and 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 Office of Science program budget justification narrative.

High-Risk, High-Reward Research[a]

The Office of Science incorporates high-risk, high-reward basic research elements in its research portfolios to drive scientific discoveries and technological breakthroughs. High-risk, high-reward research ideas that challenge current thinking, yet are scientifically sound, are integrated with other mission-driven fundamental research within the Office of Science program portfolios, projects, and individual awards. The Office of Science continues to emphasize cultivating and improving the program management practices and policies that foster support for this research. In addition to the activities noted above, Committees of Visitors consisting of panels of external subject matter experts assess the balance and impact of the portfolios triennially. Several mechanisms are used by the Office of Science to identify and develop high-reward research topics, including Federal advisory committees, program and topical workshops, interagency working groups, National Academies studies, and special Office of Science program solicitations. These activities have identified opportunities for new, compelling research and facilities and guide the programs in determining future funding priorities. As examples, some of these opportunities are captured in the following reports: *Synergistic Challenges in Data-Intensive Science and Exascale*, ASCR workshop report (2012); *From Quanta to the Continuum: Opportunities for Mesoscale Science*, by the Basic Energy Sciences Advisory Committee (BESAC) (2012); *Report of the BESAC Subcommittee on Future X-ray Light Sources* (2013); *Research at the Intersection of the Physical and Life Sciences*, by the National Research Council (2010); *Biosystems Design*, BER workshop report (2012); *Fundamental Physics at the Intensity Frontier* workshop report (2011); and *Nuclear Physics: Exploring the Heart of the Matter*, by the National Research Council (2012).

Scientific Workforce

The Office of Science and its predecessors have an over 50-year history in supporting the training of the skilled scientific workforce needed to tackle some of our Nation's most important societal challenges. In addition to the undergraduate and graduate research internship programs supported through the Office of Science's Office of Workforce Development for Teachers and Scientists, the six Office of Science 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 Office of Science 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 Committee on Science, Technology, Engineering, and Mathematics Education (CoSTEM). The Office of Science also participates in the American

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

Association for the Advancement of Science's Science & Technology Policy Fellowships program and the Presidential Management Fellows Program, supporting a limited number of highly qualified scientists to bring their technical expertise to DOE headquarters for 1–2 years.

Science
Funding by Congressional Control ($K)

	FY 2013 Current	FY 2014 Enacted	FY 2014 Adjustments	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Advanced Scientific Computing Research	**405,000**	**478,093**	**0**	**478,093**	**541,000**	**+62,907**
Basic Energy Sciences						
Research	1,504,053	1,609,929	0	1,609,929	1,667,800	+57,871
Construction						
13-SC-10 Linac Coherent Light Source-II, SLAC	0[a]	75,700	0	75,700	138,700	+63,000
07-SC-06 National Synchrotron Light Source (NSLS) II, BNL	47,203	26,300	0	26,300	0	-26,300
Total, Construction	47,203	102,000	0	102,000	138,700	+36,700
Total, Basic Energy Sciences	**1,551,256**	**1,711,929**	**0**	**1,711,929**	**1,806,500**	**+94,571**
Biological and Environmental Research	**560,657**	**609,696**	**0**	**609,696**	**628,000**	**+18,304**
Fusion Energy Sciences						
Research	377,776[b]	305,177	0	305,177	266,000	-39,177
Construction						
14-SC-60 ITER	0[b]	199,500	0	199,500	150,000	-49,500
Total, Fusion Energy Sciences	**377,776**	**504,677**	**0**	**504,677**	**416,000**	**-88,677**
High Energy Physics						
Research	715,742	745,521	0	745,521	719,000	-26,521
Construction						
11-SC-40 Long Baseline Neutrino Experiment, FNAL	3,781	16,000	0	16,000	0	-16,000
11-SC-41 Muon to Electron Conversion Experiment, FNAL	8,000	35,000	0	35,000	25,000	-10,000
Total, Construction	11,781	51,000	0	51,000	25,000	-26,000
Total, High Energy Physics	**727,523**	**796,521**	**0**	**796,521**	**744,000**	**-52,521**

[a] Prior to FY 2013, LCLS-II received funding as an MIE. FY 2013 funding was requested as a line item, but due to a Continuing Resolution, $22,500,000 in FY 2013 was executed as an MIE.
[b] ITER was established as a construction project in FY 2014. The FY 2013 appropriation included $377,776,000 as a single Congressional control containing $124,000,000 for ITER and $253,776,000 for other Fusion Energy Sciences activities.

	FY 2013 Current	FY 2014 Enacted	FY 2014 Adjustments	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Nuclear Physics						
Operation and Maintenance	466,676[a]	488,638	0	488,638	487,073	-1,565
Construction						
14-SC-50 Facility for Rare Isotope Beams, Michigan State University	0[a]	55,000	0	55,000	90,000	+35,000
06-SC-01 12 GeV CEBAF Upgrade, TJNAF	40,572	25,500	0	25,500	16,500	-9,000
Total, Construction	40,572	80,500	0	80,500	106,500	+26,000
Total, Nuclear Physics	**507,248**	**569,138**	**0**	**569,138**	**593,573**	**+24,435**
Workforce Development for Teachers and Scientists	**17,486**	**26,500**	**0**	**26,500**	**19,500**	**-7,000**
Science Laboratories Infrastructure						
Infrastructure Support						
Payment in Lieu of Taxes	1,385	1,385	0	1,385	1,412	+27
Facilities and Infrastructure	900	900	0	900	3,100	+2,200
Oak Ridge Landlord	5,934	5,951	0	5,951	5,777	-174
Total, Infrastructure Support	8,219	8,236	0	8,236	10,289	+2,053
Construction						
15-SC-75 Infrastructure and Operational Improvements at PPPL	0	0	0	0	25,000	+25,000
15-SC-76 Materials Design Laboratory at ANL	0	0	0	0	7,000	+7,000
15-SC-77 Photon Science Laboratory Building at SLAC	0	0	0	0	12,890	+12,890
15-SC-78 Integrative Genomics Building at LBNL	0	0	0	0	12,090	+12,090
13-SC-70 Utilities Upgrade, FNAL	0	34,900	0	34,900	0	-34,900
13-SC-71 Utility Infrastructure Modernization, TJNAF	0	29,200	0	29,200	0	-29,200
12-SC-70 Science and User Support Building, SLAC	14,512	25,482	0	25,482	11,920	-13,562
10-SC-70 Research Support Building and Infrastructure Modernization, SLAC	36,382	0	0	0	0	0
10-SC-71 Energy Sciences Building, ANL	32,030	0	0	0	0	0
10-SC-72 Renovate Science Lab, Phase II, BNL	14,530	0	0	0	0	0
Total, Construction	97,454	89,582	0	89,582	68,900	-20,682
Total, Science Laboratories Infrastructure	**105,673**	**97,818**	**0**	**97,818**	**79,189**	**-18,629**
Safeguards and Security	**77,506**	**87,000**	**0**	**87,000**	**94,000**	**+7,000**
Program Direction	**174,862**	**185,000**	**0**	**185,000**	**189,393**	**+4,393**

[a] The Facility for Rare Isotope Beams (FRIB) was established as a separate construction project in FY 2014. The FY 2013 Operations and Maintenance line in Nuclear Physics includes $22,000,000 in FY 2013 for FRIB and $444,676,000 for other activities.

	FY 2013 Current	FY 2014 Enacted	FY 2014 Adjustments	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Small Business Innovation Research (SC portion)	**116,088**	**0**	**0**	**0**	**0**	**0**
Subtotal, Science	**4,621,075**	**5,066,372**	**0**	**5,066,372**	**5,111,155**	**+44,783**
Small Business Innovation Research (DOE transfer)	**60,120**	**0**	**0**	**0**	**0**	**0**
Total, Science Appropriation	**4,681,195**	**5,066,372**	**0**	**5,066,372**	**5,111,155**	**+44,783**
Federal FTEs	**956**	**956**	**0**	**956**	**975**	**+19**

SBIR/STTR

- FY 2013 Current: SBIR: $102,766,000 was reprogrammed within SC and $52,771,000 was transferred from other DOE programs; STTR: $13,322,000 was reprogrammed within SC and $7,349,000 was transferred from other DOE programs.
- FY 2014 projected: SBIR: $112,366,000 and STTR: $16,053,000 (SC only).
- FY 2015 Request: SBIR: $118,426,000; STTR: $16,334,000 (SC Only).

Advanced Scientific Computing Research

Overview

The Advanced Scientific Computing Research (ASCR) program's mission is to advance applied mathematics and computer science; deliver, in partnership with disciplinary science, the most advanced computational scientific applications; advance computing and networking capabilities; and develop, in partnership with the research community, including U.S. industry, future generations of computing hardware and tools for science. The strategy to accomplish this has two thrusts: developing and maintaining world-class computing and network facilities for science; and research in applied mathematics, computer science and advanced networking.

ASCR has a strong track record in scientific computing and innovation. For example, researchers at the Department of Energy (DOE) Leadership Computing Facilities (LCFs) have achieved breakthrough scientific and technological accomplishments that would not have been feasible without petascale scientific computing capabilities. The LCFs have enabled discoveries in functional materials, fundamental studies of turbulence in chemically reacting systems, improved understanding of climate change, and advances in the understanding of the physical properties of matter, such as quark-gluon nature of nuclear matter. Researchers using ASCR facilities have modeled 3-D full-core reactor neutron transport to predict the behavior of novel nuclear fuels; conducted 3D turbulent combustion simulations of hydrocarbons to increase fuel efficiency; made U.S. airplane engines quieter, more fuel efficient and less polluting; made long haul trucks more energy efficient in record time; simulated ice formation in million-molecule water droplets to reduce the wind turbine downtime in cold climates; and are developing novel materials for extreme energy environments.

The Office of Science, through ASCR, and the National Nuclear Security Administration (NNSA) have partnered to make strategic investments in hardware, methods, and critical technologies to maintain U.S. competitiveness in high performance computing (HPC). These efforts are linked with investments to advance data-intensive science and to effectively use the massive scientific data generated by DOE's unparalleled suite of scientific user facilities and large-scale collaborations. By investing in both next-generation computing and data-intensive science, the ASCR program will enable the community of users to improve and shorten industrial design processes; design advanced materials; better understand dark matter and dark energy; explore possibilities for dramatically increasing fuel efficiency while lowering emissions; design advanced nuclear reactors that are modular, safe, and affordable; improve accuracy of climate predictions; predict and investigate how to control the behavior of fusion plasmas; and calculate the subatomic interactions that determine nuclear structure.

Highlights of the FY 2015 Budget Request

Capable exascale computing, with a hundred to thousand fold improvement in true application performance over today's systems, is the next frontier of development in High Performance Computing (HPC), extending capability significantly beyond today's petascale computers to address the next generation of scientific, engineering, and large-data problems. The goal of the exascale computing effort in SC is to provide the forefront computing resources needed to meet and advance the Department's science missions into the foreseeable future. This will require major new technology advances, the most important of which involve advances in parallelism and energy efficiency that are needed for scalable computing systems capable of sustained exaflop performance with acceptable power requirements. Research investments will impact computing at all scales from the largest scientific computers and data farms to department-scale computing to home computers and laptops.

The investment strategy has three components:

- Conduct research, development, and design efforts in hardware, software, and mathematical technologies leading toward capable exascale systems.
- Prepare today's scientific and data-intensive computing applications to migrate to and take full advantage of the emerging technologies from the research, development, and design efforts and eventually, exascale systems.

- Acquire and operate increasingly capable computing systems, starting with multi-petaflop machines that incorporate emerging technologies from research investments.

Mathematical, Computational, and Computer Sciences Research

Many of SC's user facilities and large experiments, such as light and neutron sources and the Large Hadron Collider (LHC), are moving to a distributed work environment where real-time interactions with instruments and simulations help to efficiently use facilities that often are located remotely from the control center.[a] Furthermore, experiments and simulations are often deeply intertwined as simulations help design large-scale experiments and data from experiments are used to validate or initialize simulations. The volume and complexity of data generated have increased such that a focused effort is required to develop theories, tools, and technologies to manage data from generation through integration, transformation, analysis, and visualization; to capture the historic record of the data; and to archive and share it. This request supports ASCR efforts in data-intensive science, and provides funding for a community of applied mathematicians and computer scientists to address end-to-end data management challenges.

This activity also develops hardware and software technologies and scalable system designs to broaden the impact of data-intensive science. To address the capable exascale challenge, this activity will support application development, co-design centers; research and development of software, tools, and middleware; and applied mathematics methods that address the challenges of both exascale and data-intensive science.

Software, tools, and methods from both of these efforts will be used by the Scientific Discovery through Advanced Computing (SciDAC) partnerships to more efficiently use the current and immediate next generation high performance computing facilities.

High Performance Computing and Network Facilities

Achieving a combined capability of several hundred petaflops at the LCFs requires technological advances in both hardware and software. In addition, Research and Evaluation Prototypes (REP) will support LCF-specific non-recurring engineering efforts to incorporate custom features that meet the Department's mission requirements. REP will also expand efforts in exascale component technology research and development, system engineering and integration leading to the design and development of future high performance computing (HPC) systems including prototype test beds for demonstrating the feasibility of building future full exascale systems and the exascale systems themselves.

The National Energy Research Scientific Computing Center (NERSC) will acquire the NERSC-8 supercomputer in FY 2015, which will expand the capacity of the facility by 10-40 petaflops to address emerging scientific needs. Also in FY 2015, NERSC will relocate to the Computational Research and Theory (CRT) building at Lawrence Berkeley National Laboratory.

Experienced computational scientists who assist a wide range of users in taking effective advantage of the advanced computing resources are critical assets at both the LCFs and NERSC. To address this DOE mission need, the LCFs and NERSC will work collaboratively to develop a post-doctoral training program for high end computational science and engineering.

As the Energy Science Network (ESnet) gains production experience with the 100 gigabit per second (Gbps) optical network, the need for next generation optical networking equipment has become clear. DOE is coordinating with other federal agencies to ensure the availability of next generation optical networking equipment from domestic sources. The outcomes of these efforts will help ESnet to keep pace with the continuing growth of scientific traffic from DOE's scientific user facilities.

[a] http://science.energy.gov/~/media/ascr/ascac/pdf/reports/2013/ASCAC_Data_Intensive_Computing_report_final.pdf, http://science.energy.gov/~/media/ascr/pdf/research/scidac/ASCR_BES_Data_Report.pdf, and http://science.energy.gov/~/media/ascr/pdf/research/scidac/ASCR_BES_Data_Report.pdf

Advanced Scientific Computing Research
Funding ($K)

	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Mathematical, Computational, and Computer Sciences Research					
Applied Mathematics	43,341	49,500	49,500	52,155	+2,655
Computer Science	44,299	54,580	54,580	58,267	+3,687
Computational Partnerships	41,971	46,918	46,918	46,918	0
Next Generation Networking for Science	11,779	15,931	15,931	19,500	+3,569
SBIR/STTR	0	5,518	5,518	6,035	+517
Total, Mathematical, Computational, and Computer Sciences Research	**141,390**	**172,447**	**172,447**	**182,875**	**+10,428**
High Performance Computing and Network Facilities					
High Performance Production Computing	62,000	65,605	65,605	69,000	+3,395
Leadership Computing Facilities	146,000	160,000	160,000	184,637	+24,637
Research and Evaluation Prototypes	24,000	37,784	37,784	57,934	+20,150
High Performance Network Facilities and Testbeds	31,610	32,608	32,608	35,000	+2,392
SBIR/STTR	0	9,649	9,649	11,554	+1,905
Total, High Performance Computing and Network Facilities	**263,610**	**305,646**	**305,646**	**358,125**	**+52,479**
Total, Advanced Scientific Computing Research	**405,000**	**478,093**	**478,093**	**541,000**	**+62,907**

SBIR/STTR funding:

- FY 2013 Transferred: SBIR $11,312,000 and STTR $1,466,000
- FY 2014 Projected: SBIR $13,272,000 and STTR $1,895,000
- FY 2015 Request: SBIR $15,457,000 and STTR $2,132,000

Advanced Scientific Computing Research
Explanation of Major Changes ($K)

	FY 2015 vs. FY 2014 Enacted
Mathematical, Computational, and Computer Sciences Research: Research will focus on the linked challenges of capable exascale and data-intensive science. There are increases for core research efforts in Applied Mathematics, Computer Science, and Next Generation Networking for Science for this purpose. The goal of these efforts is to develop new and improved, cross-disciplinary tools to manage and analyze massive scientific data, to initiate research and development of next generation storage technologies, and to increase support for research in managing on chip parallelism, fault tolerance and algorithm resilience, software approaches to energy management, and workflow and software environment tools.	+10,428
High Performance Computing and Network Facilities: Increase supports the NERSC move and upgrade; lease costs, increased power costs, and preparations at the LCFs to support 75-200 petaflop upgrades at each facility; and ESnet will coordinate with efforts in other agencies to develop next generation optical networking equipment. Research and Evaluation Prototypes will expand investments in critical technologies and system integration for exascale and will support LCF specific research, design, and engineering efforts to ensure user facility upgrades meet the Department's mission requirements.	+52,479
Total, Advanced Scientific Computing Research	**+62,907**

Basic and Applied R&D Coordination

Coordination across disciplines and programs is a cornerstone of the ASCR program. Partnerships within SC are mature and continue to advance the use of high performance computing and scientific networks for science. A growing area of collaboration will be in the area of data-intensive science. ASCR continues to have a strong partnership with NNSA that is essential to achieving the Department's goals for exascale computing. In April 2011, ASCR and NNSA strengthened this partnership by signing a memorandum of understanding for collaboration and coordination of exascale research within the Department. Areas of mutual interest between ASCR and the DOE technology programs, particularly the Office of Electricity Delivery and Energy Reliability and the Office of Nuclear Energy, are applied mathematics for the optimization of complex systems, control theory, and risk assessment. Through the National Information Technology Research and Development Subcommittee of the National Science and Technology Council's Committee on Technology, the interagency networking and information technology R&D coordination effort, ASCR also coordinates with programs across the Federal Government.

Program Accomplishments

Two ASCR Data Technologies Win R&D 100 Awards. Among the winners of the 2013 R&D 100 Awards are ADIOS and OSCARS. ADIOS is the Adaptable I/O System for Big Data, developed by a team from Oak Ridge National Laboratory (ORNL), Georgia Tech, and Rutgers University and supported by ASCR through both Computer Science and SciDAC working closely with the LCF staff. ADIOS is an I/O middleware package that has shown great promise helping codes scale up with improved performance. OSCARS, the On-demand Secure Circuits and Reservation System, is a software service that creates dedicated bandwidth channels to move massive, time-critical data sets around the world, the development of which was led by the Next Generation of Networking for Science research program and implemented by Department of Energy's ESnet (Energy Sciences Network).

Understanding the Long-Term Behavior of Geologically Sequestered Carbon Dioxide. Computer models running at NERSC are generating data that nearly match the quality of images taken from experiments at the SC/Basic Energy Sciences Energy Frontier Research Center for Nanoscale Control of Geologic Carbon. These data are used to predict the fate of CO_2 trapped in the subsurface over long periods of time. The key to the success of the modeling effort – and the reason massive computation is required – is its ability to simultaneously represent both movements and chemical reactions that take place at microscopic levels as the CO_2 migrates through porous rock structures. The ability to capture subsurface behavior in a computer model is also relevant to several other key DOE missions, such as hydrocarbon recovery, legacy waste stewardship, and high-level waste isolation.

Increasing Fuel Efficiency in the Near Term. Through Oak Ridge's High Performance Computing (HPC) Industrial Program, engineers developed the first 3-D Computational Fluid Dynamics optimization of the complete underhood (UH3D) package of existing cars for an American automobile manufacturer. With UH3D, researchers were able to conduct engine bay analysis for the first time with the required number of design variables and operating conditions for a true design optimization. Additionally the new process will deliver more robust cooling system designs earlier in the new car development process reducing the number of costly physical prototypes. The results provided important return-on-investments justification for a significant upgrade to the company's in-house computing resources for similar projects.

Optimizing the Grid in Real-time. The production, distribution, storage, and use of electrical energy are undergoing significant changes. Demand and production patterns are being altered radically by the advent of "smart grids," renewable generation, hybrid electric vehicles, and storage technologies. The mathematical descriptions of such systems raise numerous challenges, ranging from multiple spatial and temporal variables to uncertainty in future operating conditions. For example, the Illinois grid contains approximately 2,000 transmission nodes, 2,500 transmission lines, 900 demand nodes, and 300 generation nodes; this translates into billions of variables and constraints once the uncertainty in the supply is taken into account. New algorithms have been developed that efficiently use up to 96% of the processors on the Argonne LCF and enabled simulation of wind energy in the Illinois power grid and energy market in "real-time" (within hours). This work demonstrated that certain classes of power grid problems, namely, energy dispatch problems, can significantly benefit from existing and emerging high-performance computing architectures. The work also addressed the problem of incorporating renewable energy sources into the U.S. power grid without increasing reserve units or degrading grid performance. Their work showed that even 20% wind penetration can be accommodated without significant reserve increase.

Taking wind energy to new heights. The amount of global electricity supplied by wind, the world's fastest growing energy source, is expected to increase from 2.5% to as much as 12% by 2020. Under ideal conditions, wind farms can be three times more efficient than coal plants, but going wherever the wind blows is not always so easy. Rather than risk investing in wind turbines that might freeze during icy, cold seasons at high latitudes or at high altitudes, these regions simply don't adopt wind power—despite powerful gusts of renewable energy nipping at their fingertips. Many turbines already located in colder regions rely on small heaters in the blades to melt ice, but these heaters drain 3–5% of the energy the turbine is producing. To better understand the underlying physical changes during ice formation on various surfaces researchers used nearly 40 million hours on Titan at Oak Ridge Leadership Computing Facility (OLCF) to simulate hundreds of millions of water molecules freezing in slow motion. These simulations replicated experimental results and deepened the understanding of freezing at the molecular level. Using visualizations developed by OLCF staff, the researchers studied the nucleation (or initial budding) of ice molecules among the millions of water molecules. These detailed simulations will help experimental researchers reduce the number of time-consuming and costly physical experiments in their goal to open cold climates to renewable power.

Advanced Scientific Computing Research
Mathematical, Computational, and Computer Sciences Research

Description

The Mathematical, Computational, and Computer Sciences Research subprogram supports research activities to effectively use the current and future generations of DOE's computer and networking capabilities. Computational science is increasingly central to progress at the frontiers of science and to our most challenging engineering problems. Accordingly, the subprogram delivers:

- new mathematics required to more accurately model systems involving processes taking place across a wide range of time and length scales;
- software, tools, and middleware to efficiently and effectively harness the potential of today's high performance computing systems and advanced networks for science and engineering applications;
- operating systems, data management, analyses, representation model development, user interfaces, and other tools required to make effective use of future-generation supercomputers and the data sets from current and future scientific user facilities;
- computer science and algorithm innovations that increase the energy efficiency of future-generation supercomputers;
- networking and collaboration tools to make scientific resources readily available to scientists, in university, national laboratory, and industrial settings.

The research program will develop methods, software, and tools to use commercial products for HPC systems for data-intensive and computational science. This requires a focus on concurrency, data movement, energy management, and resiliency to address individual chip failures and to improve HPC usability up to the exascale and exabytes.

Deriving scientific insights from vast amounts of raw data will require a focused research effort that will develop the necessary theories, tools, and technologies to manage the full data lifecycle from generation or collection through integration, transformation, analysis, and visualization, to capturing the historic record of the data and archiving, and sharing it. One result of this research effort will be a community of applied mathematicians and computer scientists available to address the Department's end-to-end data management challenges.

Applied Mathematics

The Applied Mathematics activity supports the research and development of applied mathematical models, methods, and algorithms for understanding complex natural and engineered systems related to DOE's mission. These mathematical models, methods, and algorithms are the fundamental building blocks for describing physical and biological systems computationally. Applied Mathematics research underpins all of DOE's modeling and simulation efforts.

Computer Science

The Computer Science activity supports research on extreme-scale computing and extreme-scale data. Industry reports indicate that because of power constraints, data movement, rather than computational operations, will be the constraining factor for future systems. Memory per core is expected to decline sharply due to power requirements and the performance growth of storage systems will continue to lag behind the computational capability of the systems. Multi-level storage architectures that span multiple types of hardware are anticipated and require the activity to support research that develops new approaches to run-time data management and analysis.

A fundamental challenge is developing science applications to take advantage of technology advances such as multicore chips and specialized accelerator processors. This will require developing system software (operating systems, file systems, compilers, and performance tools) with more dynamic behavior than historically developed to deal with time-varying power and resilience requirements. Substantial innovation is needed to provide essential system software functionality in a timeframe consistent with the anticipated availability of hardware.

Computational Partnerships

The Computational Partnerships activity supports the SciDAC program, which accelerates progress in scientific computing through partnerships among applied mathematicians, computer scientists, and scientists in other disciplines. These partnerships enable scientists to conduct complex scientific and engineering computations on leadership-class and high-end computing systems at a level of fidelity needed to simulate real-world conditions. SciDAC applications include climate science, fusion research, high energy physics, nuclear physics, astrophysics, materials science, chemistry, and accelerator physics.

SciDAC focuses on the high end of high performance computational science and engineering and addresses two challenges: to broaden the community and thus the impact of high performance computing, particularly to address the Department's missions and to ensure that further progress at the forefront is enhanced rather than curtailed by advances in computing hardware, most pressingly, the emergence of hybrid, multi-core architectures. SciDAC has helped U.S. industry to use computing to improve competitiveness.

Next Generation Networking for Science

ASCR has played a leading role in the development of the high-bandwidth networks connecting researchers to facilities, data, and one another. ASCR-supported researchers helped establish critical protocols on which the internet is based. Next Generation Networking for Science research makes possible international collaborations such as the Large Hadron Collider and underpins virtual meeting and other commercial collaboration tools. These research efforts build upon results from Computer Science and Applied Mathematics to develop integrated software tools and advanced network services to use new capabilities in ESnet to advance DOE missions.

Activities and Explanation of Change

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Applied Mathematics		
Significant innovation in applied mathematics is needed to realize the potential of next generation high performance computing systems. The Applied Mathematics portfolio will shift toward investments aimed at addressing these critical research challenges, as well as associated challenges in complex systems and data–intensive science. Energy management, data movement, and resiliency research will be emphasized.	High-fidelity modeling and simulation will require a number of new algorithmic techniques and strategies supported by this activity, including: advanced solvers for large linear and nonlinear systems, time integration schemes, multi-physics coupling, methods that use asynchrony or randomness, adaptively, algorithmic resilience, and strategies for reducing global communications.	Increased research efforts support the Department's efforts in capable exascale and data-intensive science. These efforts will develop scalable mathematical and statistical models, algorithms, and methods for the representation, analysis, and understanding of extreme-scale data from scientific simulations and experiments.
Computer Science		
Significant innovation in computer science is needed to realize the potential of next generation high performance computing (HPC) systems and other scientific user facilities. There will be continued emphasis on data-intensive science challenges with particular attention to the intersection with exascale computing challenges and the unique needs of DOE scientific user facilities including data management. There will also be expanded efforts in tools, user interfaces, the high performance computing software stack, and visualization and analytics. These efforts are essential to ensure DOE mission applications are able to use commercially available HPC hardware.	To achieve the full potential of exascale computing, a software stack must be developed that includes new programming models and metrics for evaluating system status. This activity will support software efforts that span the spectrum from low-level, operational software to high-level, application development environments. More specifically, it will include operating systems, runtimes for scheduling, memory management, file systems, and performance monitoring. Also included are power management and resilience strategies, computational libraries, compilers, programming models, and application frameworks. Scalability, programmability, resilience, and code portability will be emphasized to promote ease of use, reliability, accommodation of legacy code, and pathways to future development beyond exascale.	Increased research efforts support the Department's efforts in capable exascale and data-intensive science. These efforts will focus on in situ data management, analysis and visualization, new I/O subsystems, and new multi-level storage system software.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Computational Partnerships		
The SciDAC institutes continue to play a key role in assisting DOE mission critical applications to effectively use the ASCR production and leadership computing facilities. The strategic partnerships with the other Office of Science programs will continue to address their specific needs as they move toward larger data sets and more complex computing systems. This activity will also focus on the current set of co-design centers that partner DOE mission applications with forefront researchers and computing vendors. These efforts will inform core research efforts in applied mathematics and computer science as well as the computing resources for the next generation of scientific user facilities.	The Scalable Data Management Analysis and Visualization (SDAV) Institute and data-intensive co-design center will continue to support efforts in the Department's efforts in data-intensive science. The role of this activity is to develop robust tools and software to manage and analyze massive data with SDAV focused on the near term and co-design focused on emerging hardware.	
Next Generation Networking for Science		
With the production deployment of 100 gigabit per second (Gbps) technologies, research will continue to focus on developing networking software, middleware, and hardware that delivers 99.999% reliability while allowing the successful products of prior research to transition into operation. These investments are increasingly important as ESnet expands production use of very high-throughput and optical technologies.	Research will focus on the challenges of moving, sharing, and validating massive quantities of data from DOE scientific user facilities and large scale collaborations via high speed optical networks. This includes the challenges in building, operating, and maintaining the network infrastructure over which these data pass.	Increased research efforts support the Department's efforts in exascale and data-intensive science. This activity will focus on integrating the SC facilities with computing resources and mechanisms for discovering resources and data in a globally distributed computing environment.
SBIR/STTR		
SBIR/STTR funding is set at 3.2% of non-capital funding in FY 2014.	In FY 2015, SBIR/STTR funding is set at 3.3% of non-capital funding.	The SBIR/STTR amount is adjusted to mandated percentage for non-capital funding.

Advanced Scientific Computing Research
High Performance Computing and Network Facilities

Description

The High Performance Computing and Network Facilities subprogram delivers forefront computational and networking capabilities. These include high performance production computing at the National Energy Research Scientific Computing Center (NERSC) at LBNL and Leadership Computing Facilities (LCFs) at ORNL and ANL. These computers and the other SC research facilities generate many petabytes of data each year. Moving data to the researchers who need them requires advanced scientific networks and related technologies provided through High Performance Network Facilities and Testbeds, which includes the Energy Science network (ESnet). The Research and Evaluation Prototypes activity invests in research and development that will play a critical role in delivering world-leading capabilities and achieving the Department's exascale computing goals.

Allocations on ASCR facilities provide critical resources for the scientific community, including industry and other agencies, following the peer reviewed, public access model used by other SC scientific user facilities. ASCR facilities provide a testbed for U.S. industry to scale and then validate code performance to optimize in-house HPC investments.

The Research and Evaluation Prototypes activity addresses the challenges of next generation computing systems. By actively partnering with the research community, including industry, on the development of technologies that enables next-generation machines, ASCR ensures that commercially available architectures serve the needs of the scientific community. Coupling this activity to the co-design centers ensures that application and software researchers can gain a better understanding of future systems to get a head start in developing software and models to take advantage of the new capabilities. Research and Evaluation Prototypes prepares researchers to effectively use the next generation of scientific computers and seeks to reduce risk for future major procurements.

High Performance Production Computing

This activity supports NERSC, which delivers high-end production computing services for the SC research community. Annually, approximately 5,000 computational scientists in about 500 projects use NERSC to perform scientific research across a wide range of disciplines including astrophysics, chemistry, climate modeling, materials, high energy and nuclear physics, and biology. NERSC users come from nearly every state in the U.S., with about 65% based in universities, 25% in DOE laboratories, and 10% in other government laboratories and industry. NERSC's large and diverse user base requires an agile support staff to aid users entering the high performance computing arena for the first time, as well as those preparing codes to run on the largest machines available at NERSC and other SC computing facilities.

NERSC is a vital resource for the SC research community and it is consistently oversubscribed, with requests exceeding capacity by a factor of 3–10. This gap between demand and capacity exists despite upgrades to the primary computing systems approximately every 3 years. NERSC regularly gathers requirements from SC programs through a robust process that informs NERSC upgrade plans. These requirements activities are also vital to planning for SciDAC and other ASCR efforts to prioritize research directions and inform the community of new computing trends, especially as the computing industry moves toward heterogeneous, multi-core computing.

Leadership Computing Facilities

The LCFs enable open scientific applications, including industry applications, to harness the potential of leadership computing to advance science and engineering. The era of petaflop science opened significant opportunities to dramatically advance research as simulations more realistically capture complex behavior in natural and engineered systems. The success of this effort is built on the gains made in Research and Evaluation Prototypes and ASCR research efforts. LCF staff operates and maintains forefront computing resources. One LCF strength is the staff support provided to Innovative and Novel Computational Impact on Theory and Experiment (INCITE) projects, ASCR Leadership Computing Challenge projects, scaling tests, early science applications, and tool and library developers. Support staff experience is critical to the success of industry partnerships to address the challenges of next-generation computing.

The Oak Ridge Leadership Computing Facility (OLCF) 27 petaflop system is one of the most powerful computers in the world for scientific research, according to the June 2013 Top 500 list. Through INCITE allocations, several applications, including combustion studies in diesel jet flame stabilization, simulations of neutron transport in fast-fission reactor cores, and groundwater flow in porous media, are running at the multi-petaflop scale. OLCF staff is sharing its expertise with industry to broaden the benefits for the Nation. For example, OLCF worked with industry to significantly reduce the need for costly physical prototypes and physical tests to design energy efficient cooling systems leading to increased fuel efficiency in vehicles.

The Argonne Leadership Computing Facility (ALCF) operates a 10 petaflop IBM Blue Gene Q (Mira) machine with relatively low electrical power requirements. The IBM Blue Gene/Q was developed through a joint research project with support from the NNSA, industry, and ASCR's Research and Evaluation Prototypes activity.

The ALCF and OLCF systems are architecturally distinct and this diversity of resources benefits the Nation's HPC user community. ALCF supports many applications, including molecular dynamics and materials, for which it is better suited than OLCF or NERSC. Through INCITE, ALCF also transfers its expertise to industry, for example, helping engineers understand the fundamental physics of turbulent mixing to transform product design and to achieve improved performance, life and efficiency.

The demand for 2014 INCITE allocations at the LCFs outpaced the available resources by a factor of three.

Research and Evaluation Prototypes

The next generation of computing hardware will present new challenges for science and engineering applications—most notably higher levels of concurrency involving billions of processing elements, effectively managing chip failures and silent errors, and power demands that will restrict memory usage. This activity supports research and development partnerships with vendors to influence and accelerate critical technologies for next-generation systems, system integration research, and development and engineering efforts that are coupled to application development to ensure Department applications are ready to make effective use of commercial offerings.

In addition, this activity partners with the NNSA to support research investments in non-recurring engineering, for near-term technology customization for the ASCR facilities.

High Performance Network Facilities and Testbeds

The Energy Sciences Network (ESnet) provides the national network and networking infrastructure connecting DOE science facilities and SC laboratories with other institutions connected to peer academic or commercial networks. The costs for ESnet are dominated by operations, including maintaining the fiber optic backbone and refreshing switches and routers on the schedule needed to ensure the 99.999% reliability required for large-scale scientific data transmission. Additional funds are used to support the growth in science data traffic and for testing and evaluation of new technologies and services that will be required to keep pace with the expected data volume. DOE is coordinating with other federal agencies to ensure the availability of next generation optical networking equipment from domestic sources. The outcomes of these efforts will help ESnet to keep pace with the continuing growth of scientific traffic from DOE's scientific user facilities.

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
High Performance Production Computing		
Supports operation of the NERSC capability systems (NERSC-7) including power costs, lease payments, and user support. Also supports, as part of the NERSC-7 upgrade project, continued site preparations for the new NERSC facility on the LBNL campus.	Supports operation of the NERSC high-end capability systems (NERSC-7) including increased power costs, lease payments, and user support and a new post-doctoral training program for high-end computational science and engineering.	Increase supports operations, lease payments, and user support for NERSC including NERSC-7, which will more than double the capacity of NERSC but also increases the power requirement of NERSC. Also supports the move into the Computational Research and Theory building. Also supports initiation of a post-doctoral training program for high-end computational science and engineering.
Leadership Computing Facilities		
Supports operation and allocation, through INCITE and ALCC, of the upgraded 20 petaflop OLCF and 10 petaflop ALCF. This includes lease payments, power, and user support.	Supports operation and allocation, through INCITE and ALCC, of the 27 petaflop Titan system at the OLCF and 10 petaflop Mira system at the ALCF. This includes lease payments, power, and user support. Also supports preparations at the LCFs to support 75-200 petaflop upgrades at each facility and a new post-doctoral training program for high-end computational science and engineering.	Increase also supports operations, lease payments, additional power costs, and user support for the 27 petaflop system at the OLCF and 10-petaflop machine at the ALCF and preparations for the next upgrades. Also supports initiation of a post-doctoral training program for high-end computational science and engineering.
Leadership Computing Facility at ANL: $67,000	$80,320	+$13,320
Leadership Computing Facility at ORNL: $93,000	$104,317	+$11,317

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Research and Evaluation Prototypes		
Research and Evaluations Prototypes (REP) will continue joint investments between ASCR and NNSA's Advanced Simulation and Computing (ASC) program in the *Fast Forward* critical technology effort, whose primary objective is to form partnerships with industry to accelerate the R&D of critical component technologies needed for extreme-scale computing. The selected technologies have the potential to impact low-power embedded, cloud/datacenter, and mid-range HPC applications, thus ensuring that DOE/NNSA investment furthers a sustainable software/hardware ecosystem supported by applications across the HPC market and the broader IT industry. As part of the *Fast Forward* effort, REP will initiate investments exploring early exascale system design and analysis of interconnect design trade-offs.	As follow-ons to the previous research efforts in critical technologies and system interconnect, REP will competitively select teams to develop system designs suitable for next-generation platforms. In addition, it will fund the development of prototypes based on the results from the *Fast Forward* program's investments in critical crosscutting technology research in areas such as processors, memory subsystems, network interfaces and the interconnection network.	Increase supports the initiation of system design and prototype development efforts. Increase also supports LCF specific non-recurring engineering efforts to ensure the planned LCF upgrades meet the Department's mission requirements.
High Performance Network Facilities and Testbeds		
ESnet will operate the network infrastructure to support critical DOE science applications and SC facilities. ESnet extends deployment of 100 Gbps production network by connecting remaining SC laboratories at 100 Gbps speeds.	ESnet will operate the network infrastructure to support critical DOE science applications, SC facilities and scientific collaborations around the world through 100 Gbps production network.	DOE is coordinating with other federal agencies to ensure the availability of next generation optical networking equipment from domestic sources. These efforts will ensure ESnet keeps pace with continuing growth of scientific traffic from DOE's scientific user facilities and scientific collaborations. Also supports lighting of additional 100 GBS fiber to support interim traffic growth.
SBIR/STTR		
SBIR/STTR funding is set at 3.2% of non-capital funding in FY 2014.	In FY 2015, SBIR/STTR funding is set at 3.3% of non-capital funding.	The SBIR/STTR amount is adjusted to mandated percentage for non-capital funding.

Advanced Scientific Computing Research
Performance Measures

In accordance with the GPRA Modernization Act of 2010, the Department sets targets for, and tracks progress toward, achieving performance goals for each program. For more information, refer to the Department's FY 2013 Annual Performance Report. The following table shows the targets for FY 2013 through 2015.

	FY 2013	FY 2014	FY 2015
Performance Goal (Measure)	**ASCR Facility Operations—Average achieved operation time of ASCR user facilities as a percentage of total scheduled annual operation time**		
Target	≥ 90%	≥ 90%	≥ 90%
Result	Met	TBD	TBD
Endpoint Target	Many of the research projects that are undertaken at the Office of Science's scientific user facilities take a great deal of time, money, and effort to prepare and regularly have a very short window of opportunity to run. If the facility is not operating as expected the experiment could be ruined or critically setback. In addition, taxpayers have invested millions or even hundreds of millions of dollars in these facilities. The greater the period of reliable operations, the greater the return on the taxpayers' investment.		
Performance Goal (Measure)	**ASCR Research—Discovery of new applied mathematics and computer science tools and methods that enable DOE applications to deliver scientific and engineering insights with a significantly higher degree of fidelity and predictive power**		
Target	Accept and put into service 10 petaflop upgrades at Argonne and Oak Ridge Leadership Computing Facilities	Initiate at least four new teams to conduct fundamental computer science research and at least three new applied mathematics research awards that address issues of fault tolerance or energy management for next-generation computing systems	Conduct an external peer review of the three original co-design centers to document progress, impact, and lessons learned.
Result	Met	TBD	TBD
Endpoint Target	Develop and deploy high-performance computing hardware and software systems through exascale platforms.		

Advanced Scientific Computing Research
Capital Summary ($K)

	Total	Prior Years	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Capital operating expenses							
Capital equipment	n/a	n/a	0	4,100	4,100	8,000	+3,900

Funding Summary ($K)

	FY 2013 Current	FY 2014 Enacted	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Research	165,390	204,713	234,774	+30,061
Scientific user facility operations	239,610	258,213	288,637	+30,424
Other	0	15,167	17,589	+2,422
Total, Advanced Scientific Computing Research	**405,000**	**478,093**	**541,000**	**+62,907**

Scientific User Facility Operations ($K)

	FY 2013 Current	FY 2014 Enacted	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
NERSC	$62,000	$65,605	$69,000	+$3,395
Achieved operating hours	N/A	N/A	N/A	
Planned operating hours	8,585	8,585	8,585	0
Optimal hours	8,585	8,585	8,585	0
Percent of optimal hours	100%	100%	100%	
Unscheduled downtime percentage	1%	1%	1%	
Number of users	5,000	5,500	5,500	0

	FY 2013 Current	FY 2014 Enacted	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
OLCF	$85,000	$93,000	$104,317	+$11,317
Achieved operating hours	N/A	N/A	N/A	
Planned operating hours	7,008	7,008	7,008	0
Optimal hours	7,008	7,008	7,008	0
Percent of optimal hours	100%	100%	100%	
Unscheduled downtime percentage	2%	1%	1%	
Number of users	1,200	1,300	1,300	0
ALCF	$61,000	$67,000	$80,320	+$13,320
Achieved operating hours	N/A	N/A	N/A	
Planned operating hours	7,008	7,008	7,008	0
Optimal hours	7,008	7,008	7,008	0
Percent of optimal hours	100%	100%	100%	
Unscheduled downtime percentage	2%	1%	1%	
Number of users	900	1,000	1,000	0
ESnet	$31,610	$32,608	$35,000	+$2,392
Achieved operating hours	N/A	N/A	N/A	
Planned operating hours	8,760	8,760	8,760	0
Optimal hours	8,760	8,760	8,760	0
Percent of optimal hours	100%	100%	100%	
Unscheduled downtime percentage	0.01%	0.01%	0.01%	
Number of users[a]	N/A	N/A	N/A	0
Total, Scientific User Facility Operations	$239,610	$258,213	$288,637	+$30,424
Achieved operating hours	N/A	N/A	N/A	
Planned operating hours	31,361	31,361	31,361	0
Optimal hours	31,361	31,361	31,361	0
Percent of optimal hours (funding weighted)	100%	100%	100%	
Unscheduled downtime percentage	1%	1%	1%	
Number of users	7,100	7,800	7,800	0

[a] ESnet is a high performance scientific network connecting DOE facilities to researchers around the world; user statistics are not collected.

Scientific Employment

	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	FY 2015 vs FY 2014
Number of graduate students (FTEs)	510	400	440	+40
Number of permanent Ph.D.'s (FTEs)	725	650	720	+70
Other scientific employment (FTEs)	255	220	245	+25

Basic Energy Sciences

Overview

The mission of the Basic Energy Sciences (BES) program is to support 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 and to support DOE missions in energy, environment, and national security.

The research disciplines that BES supports—condensed matter and materials physics, chemistry, geosciences, and aspects of physical biosciences—are those that discover new materials and design new chemical processes that touch virtually every important aspect of energy resources, production, conversion, transmission, storage, efficiency, and waste mitigation. BES research provides a knowledge base to help understand, predict, and ultimately control the natural world and helps build the foundation to achieve the vision of a secure and sustainable energy future. BES also supports world-class, open-access scientific user facilities consisting of a complementary set of intense x-ray sources, neutron sources, and research centers for nanoscale science. BES facilities probe materials with ultrahigh spatial, temporal, and energy resolutions to interrogate the critical functions of matter—transport, reactivity, fields, excitations, and motion—and answer some of the most challenging grand science questions. BES-supported activities are entering a new era in which materials can be built with atom-by-atom precision and computational models can predict the behavior of materials before they exist.

As history has shown, breakthroughs in clean energy technologies will likely be built on a foundation of basic research advances. Key to exploiting such discoveries is the ability to create new materials using sophisticated synthesis and processing techniques, precisely define the atomic arrangements in matter, and control physical and chemical transformations. The energy systems of the future—whether they tap sunlight, store electricity, or make fuel by splitting water or reducing carbon dioxide—will revolve around materials and chemical changes that convert energy from one form to another. Such materials will need to be more functional than today's energy materials. To control chemical reactions or to convert a solar photon to an electron requires coordination of multiple steps, each carried out by customized materials with designed nanoscale structures. Such advanced materials are not found in nature; they must be designed and fabricated to exacting standards using principles revealed by basic science.

Highlights of the FY 2015 Budget Request

In FY 2015, BES will support ongoing core research activities at approximately the FY 2014 level. A new activity on computational materials sciences is proposed that will support integrated theoretical modeling and experimental research to develop community codes and research-oriented software for predictive design of functional materials. The Energy Frontier Research Centers (EFRCs) funding will continue at the FY 2014 level, and funding for the Energy Innovation Hubs will continue as planned.

The FY 2015 budget request reflects choices between operating existing facilities, upgrading facilities, and building new user facilities. In FY 2015, BES will support the optimal operations of four light source facilities, two neutron source facilities, and five Nanoscale Science Research Centers (NSRCs). Funding will be increased to continue early operations of the National Synchrotron Light Source-II (NSLS-II) as it transitions from a construction project to operations in FY 2015. Construction funding for NSLS-II will be ramped down as the project is completed in FY 2015, as scheduled. The National Synchrotron Light Source (NSLS) will cease operations and funds are provided to transition the facility to a safe storage condition in FY 2015. The BES operations at the Lujan Neutron Scattering Center will cease and funding is requested to transition the facility to a safe storage condition. The three electron beam microcharacterization centers will be merged administratively with their respective neighboring NSRCs in FY 2015. The Advanced Photon Source Upgrade (APS-U) and the NSLS-II Experimental Tools (NEXT) major item of equipment (MIE) projects will be supported. The Linac Coherent Light Source-II (LCLS-II) construction project scope will be modified to include the addition of a superconducting linear accelerator and additional undulators to deliver an unprecedented high-repetition-rate free-electron laser that will solidify the Linac Coherent Light Source complex as the world leader in ultrafast x-ray science for a decade or more.

In FY 2015, the Chemical Transformations activity will collaborate with the Offices of Energy Efficiency and Renewable Energy, Fossil Energy, Electricity Delivery and Energy Reliability, and Nuclear Energy on a crosscutting initiative on subsurface engineering.

Basic Energy Sciences
Funding ($K)

	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Materials Sciences and Engineering					
Scattering and Instrumentation Sciences Research	61,731	64,022	64,022	64,022	0
Condensed Matter and Materials Physics Research	120,946	120,946	120,946	120,946	0
Materials Discovery, Design, and Synthesis Research	73,983	73,983	73,983	73,983	0
Experimental Program to Stimulate Competitive Research (EPSCoR)	8,416	9,953	9,953	8,520	-1,433
Energy Frontier Research Centers (EFRCs)	57,320	58,000	58,000	58,000	0
Energy Innovation Hubs—Batteries and Energy Storage	24,237	24,237	24,237	24,175	-62
Computational Materials Sciences	0	0	0	24,175	+24,175
SBIR/STTR	0	11,608	11,608	12,757	+1,149
Total, Materials Sciences and Engineering	**346,633**	**362,749**	**362,749**	**386,578**	**+23,829**
Chemical Sciences, Geosciences, and Biosciences					
Fundamental Interactions Research	72,757	75,999	75,999	75,999	0
Chemical Transformations Research	93,531	93,531	93,531	93,531	0
Photochemistry and Biochemistry Research	69,556	69,556	69,556	69,556	0
Energy Frontier Research Centers (EFRCs)	42,680	42,000	42,000	42,000	0
Energy Innovation Hubs—Fuels from Sunlight	24,237	24,237	24,237	24,175	-62
General Plant Projects (GPP)	5,950	600	600	600	0
SBIR/STTR	0	10,093	10,093	10,417	+324
Total, Chemical Sciences, Geosciences, and Biosciences	**308,711**	**316,016**	**316,016**	**316,278**	**+262**
Scientific User Facilities					
Synchrotron Radiation Light Sources	396,170	432,000	432,000	484,166	+52,166
High-Flux Neutron Sources	246,448	245,900	245,900	248,490	+2,590

	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Nanoscale Science Research Centers (NSRCs)	100,500	100,885	100,885	118,798	+17,913
Other Project Costs	24,400	37,400	37,400	9,300	-28,100
Major Items of Equipment	54,500	45,000	45,000	42,500	-2,500
Research	26,691	42,498	42,498	32,168	-10,330
SBIR/STTR	0	27,481	27,481	29,522	+2,041
Total, Scientific User Facilities	**848,709**	**931,164**	**931,164**	**964,944**	**+33,780**
Subtotal, Basic Energy Sciences	**1,504,053**	**1,609,929**	**1,609,929**	**1,667,800**	**+57,871**
Construction					
Linac Coherent Light Source-II (LCLS-II), SLAC	0	75,700	75,700	138,700	+63,000
National Synchrotron Light Source-II (NSLS-II), BNL	47,203	26,300	26,300	0	-26,300
Total, Construction	**47,203**	**102,000**	**102,000**	**138,700**	**+36,700**
Total, Basic Energy Sciences	**1,551,256**	**1,711,929**	**1,711,929**	**1,806,500**	**+94,571**

SBIR/STTR Funding:

- FY 2013 transferred: SBIR $39,756,000 and STTR $5,154,000 (transferred out of BES in FY 2013 Current column)
- FY 2014 projected: SBIR $43,035,000 and STTR $6,147,000
- FY 2015 Request: SBIR $46,309,000 and STTR $6,387,000

Basic Energy Sciences
Explanation of Major Changes ($K)

	FY 2015 vs. FY 2014 Enacted
Materials Sciences and Engineering: Core research activities will be supported at approximately the same level as FY 2014. The Batteries and Energy Storage Hub and Energy Frontier Research Centers will continue at the planned level. A new activity for computational materials sciences will be initiated that emphasizes integrated theoretical and experimental research, approaches to derive new knowledge from large experimental and theory/modeling data sets, and community software to accelerate discovery and advancement of functional materials for energy-use inspired applications.	+23,829
Chemical Sciences, Geosciences, and Biosciences: Core research activities will be supported at approximately the same level as FY 2014. The Energy Frontier Research Centers will continue at the planned level. The Fuels from Sunlight Hub receives the final year of funding for its five-year award term at the planned level in FY 2014. A decision for continued funding beyond the initial five year term, which ends in September 2015, will be made in FY 2015.	+262
Scientific User Facilities: BES will increase support for the operations of four light sources, five Nanoscale Science Research Centers (NSRCs), and two neutron sources at optimal levels. Funding will increase for early operations of the National Synchrotron Light Source-II (NSLS-II) that will transition from a construction project to operations in FY 2015. The National Synchrotron Light Source (NSLS) will cease operations and funds are provided to transition the facility to a safe storage condition in FY 2015. The BES operations at the Lujan Neutron Scattering Center will cease and funds are provided to transition the facility to a safe storage condition. The three electron beam microcharacterization centers will be merged administratively with their respective neighboring NSRCs in FY 2015. Funding for the APS Upgrade and NEXT MIE projects will continue per the project plans. Funding for Other Project Costs (OPC) for the LCLS-II construction project will decrease per the project plans.	+33,780
Construction: Construction of the NSLS-II will be ramped down as the project is completed in FY 2015, as scheduled. Construction of the LCLS-II will continue, as scheduled.	+36,700
Total, Basic Energy Sciences	**+94,571**

Basic and Applied R&D Coordination

As a fundamental research program within the Department of Energy, BES strives to build and maintain close connections with other DOE program offices. The Department facilitates coordination between DOE R&D programs through a variety of Departmental activities, including joint participation in research workshops, strategic planning activities, solicitation development, and program review meetings. For example, the DOE Hub Working Group meets regularly to coordinate programmatic oversight and promote commonality across the DOE Energy Innovation Hubs. BES also coordinates with DOE technology offices on the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) program, including the topical area planning, solicitations, reviews, and award selections.

BES program managers regularly participate in intra-departmental meetings for information exchange and coordination on solicitations, program reviews, and project selections in the research areas of biofuels derived from biomass; solar energy utilization; building technologies, including solid-state lighting; advanced nuclear energy systems and advanced fuel cycle technologies; vehicle technologies; improving efficiencies in industrial processes; and superconductivity for grid applications. These activities facilitate cooperation and coordination between BES and the DOE technology offices and defense programs. DOE program managers have also established formal technical coordination working groups that meet on a regular basis to discuss R&D programs with wide applications for basic and applied programs including the Office of Environmental Management. Additionally, DOE technology office personnel participate in reviews of BES research, and BES personnel participate in reviews of research funded by the technology offices and ARPA-E. In FY 2015, Departmental leadership has identified crosscutting activities of particular emphasis for coordination between DOE programs. BES will collaborate with the Offices of Energy Efficiency and Renewable Energy, Fossil Energy, Electricity Delivery and Energy Reliability, and Nuclear Energy on a crosscut on subsurface engineering.

Co-funding and co-siting of research by BES and DOE technology programs at the same institutions has proven to be a valuable approach to facilitate close integration of basic and applied research. In these cases, teams of researchers benefit by sharing expertise and knowledge of research breakthroughs and program needs. The Department's national laboratory system plays a particularly important role in achieving integration of basic and applied research.

Program Accomplishments

Designing new materials. Understanding how to control the structure and composition of materials is foundational to the design of better materials. Major advances have recently been made across a wide spectrum of materials, such as:

- Using a combination of theory and experiment, extreme nano-structuring (e.g., fabricating very narrow wires or thin films perforated with many holes) was found to improve the performance of superconductors—materials which conduct electricity with no losses—in high magnetic fields. Nanostructured superconductors hold promise for practical use in the electricity grid and developing powerful electric motors.
- A new approach to self-assembly has provided 3-dimensional hierarchical architectures made-up of functionalized graphene (single layers of carbon atoms) with nanometer sized and larger diameter pores. The modified material exhibits enhanced electrochemical activity for possible use in high-capacity lithium-air batteries.
- Neutron scattering has uncovered the role of water in controlling the assembly of molecules, opening new avenues to control nanostructure in protein-based materials with important potential applications in bio-catalysis and energy conversion.

Ultrafast x-rays elucidate chemical transformations. The ultrashort x-ray pulses produced by the Linac Coherent Light Source (LCLS) at SLAC National Accelerator Laboratory are enabling unprecedented investigations into fundamental chemical processes for a wide range of important energy systems.

- By capturing short-time snapshots of a catalytic process, scientists proved the existence of transient precursor species on a catalytic surface, providing a missing link in the understanding of molecular-level chemical catalytic mechanisms and facilitating catalyst design for highly-efficient and selective chemical conversions.

- The high intensity of the x-ray pulses and their coherence has made possible imaging of individual aerosol particles in their airborne state, revealing structures of surprising diversity and complexity.
- Atomic positions and electronic structure were simultaneously analyzed in photo-activated Photosystem II, which is a key photosynthetic complex that converts light into chemical energy.

Scientific advances enable cleaner fossil energy. There continue to be scientific challenges to cleaner delivery of fossil energy. Among these are the design and discovery of new processes and materials for chemical separations, more reliable and effective carbon capture, and safe injection of carbon dioxide into geologic formations. Recent research results at the EFRCs have advanced the science in a number of areas, such as:

- New classes of novel molecular compounds have been discovered that can be functionalized to enable energy-efficient, lower-cost hydrocarbon separation with the potential to replace current energy-intensive gas separation processes.
- Computer simulations have screened thousands of possible materials and revealed promising options for the efficient separation of carbon dioxide from coal power plants and for methane capture from dilute and medium-concentration sources.
- Monitoring sub-surface carbon dioxide migration after geologic sequestration has been enabled by high-resolution seismic imaging and new computational algorithms.
- To further enhance understanding of how geological formations interact with stored carbon dioxide, experiments and computational modeling have been applied to derive a new fundamental understanding of how nanoscale features of rock surfaces control the growth and distribution of solid carbonates, the favored form of carbon sequestration in geologic formations.

Generating electricity from waste heat. Roughly 60% of the energy used in the world ends up as waste heat. Devices based on thermoelectric materials can convert waste heat to electricity. Research efforts at the EFRCs are addressing the scientific breakthroughs needed to control the flow of heat and electricity in these materials, advances that are critical to increasing the efficiency and decreasing the cost of thermoelectric devices.

- Experiments and theoretical models have demonstrated that the vibrations that carry heat across materials can travel in a wavelike fashion through a stack of thin films, suggesting new ways to engineer thermoelectric materials.
- Other experiments confirmed theoretical predictions that substituting specific atoms in materials reduces the thermal conductivity, providing an alternate approach to improve device efficiency.
- Use of earth abundant minerals in thermoelectric applications could significantly reduce manufacturing costs; theoretical modeling has made significant advances in this area, guiding the synthesis of new thermoelectric materials based on earth abundant minerals that perform comparably to existing thermoelectric materials.

New capabilities at light source facilities enable ground breaking science. From the powerful x-ray laser to an innovative device, researchers from various scientific communities employing instrumentation at synchrotron light sources to accomplish significant scientific discoveries.

- Researchers have demonstrated for the first time how to produce pairs of x-ray laser pulses in slightly different wavelengths with finely adjustable time intervals between them. Each of the paired x-ray laser pulses can be tuned to study a specific element in atomic detail, and they can be timed to hit a sample in very quick succession. This capability opens up a new realm of experiments at the Linac Coherent Light Source, potentially revealing how bonds between atoms form, break and rearrange, and how atoms absorb light on ultrafast time scales of less than 25 femtoseconds.
- A prototype superconducting undulator has successfully delivered first hard x-rays at the Advanced Photon Source. The new undulators can achieve twice the x-ray energy of existing devices, while still maintaining sufficient magnetic fields to provide high flux of hard x-rays. This breakthrough achievement has realized a long-standing objective of accelerator science to take advantage of the high current densities made possible by superconducting magnet technology to greatly enhance the performance of synchrotron light sources.

- The 2012 Nobel Prize in Chemistry was awarded for the breakthrough studies of G-protein-coupled receptors (GPCRs) enabled by advanced instruments at the Advanced Photon Source. GPCRs are a large set of proteins embedded in a cell's membrane that sense molecules outside the cell and activate a cascade of different cellular processes in response. They constitute key components of how cells interact with their environments and are the target of nearly half of today's pharmaceuticals.

BES user facilities assist industry to advance technologies and develop new drugs. Researchers from industry use the unique capabilities provided at the BES scientific user facilities to develop new technologies and new drugs that impact lives. BES researchers have collaborated with industry to:

- Combine a new low-temperature nanocrystalline diamond deposition technology and an efficient semiconductor doping process to produce highly n-type diamond films. The combination of this novel nanomaterial synthesis and understanding of the material structural and electronic properties are fundamental to realizing efficient very high power electronic devices. The research opens a commercially feasible approach to produce cheaper and better integrated circuits that could potentially transform energy, telecommunications, defense, and aviation electronics.
- Employ the protein crystallography techniques available at BES synchrotron light sources to understand how diseases function and to develop potential drugs for treatment. BES light source facilities have played a crucial role for those developments, such as a recently FDA-approved drug that treats type 2 diabetes in adults and a cancer drug, an angiogenesis inhibitor, that interferes with the growth of new blood vessels needed for solid cancer tumors to survive.
- Study the pore structure of oil and gas containing Barnett shale using small angle neutron scattering at the High Flux Isotope Reactor. The researchers analyzed the pore size distribution in different shale samples and the percentage of pores accessible to methane and water. The results helped shed light on why shales of similar compositions produced differing amounts of gas, and could inform the fracking process.

Description

Materials are critical to nearly every aspect of energy generation and end-use. Materials limitations are often the barrier to improved energy efficiencies, longer lifetimes of infrastructure and devices, or the introduction of new energy technologies. The *Materials Sciences and Engineering* subprogram supports research to provide the understanding of materials synthesis, behavior, and performance that will enable solutions to these wide-ranging challenges as well as opening new directions that are not foreseen based on existing knowledge. The research explores the origin of macroscopic material behaviors; their fundamental connections to atomic, molecular, and electronic structures; and their evolution as materials move from nanoscale building blocks to mesoscale systems. At the core of the subprogram is the quest to enable the predictive design and discovery of new materials with novel structures, functions, and properties. Such understanding and control are critical to science-guided design of highly efficient energy conversion processes, such as the conversion of sunlight to electricity, new electromagnetic pathways for enhanced light emission in solid-state lighting, and multi-functional nanoporous structures for optimum ionic and electronic transport in batteries and fuel cells.

To accomplish these goals, the portfolio includes three integrated research activities:

- **Scattering and Instrumentation Sciences**—Advancing new tools and techniques to characterize and correlate materials performance, structure, and dynamics on multiple time and length scales and in the environments in which materials are used.
- **Condensed Matter and Materials Physics**—Understanding the foundations of material functionality and behavior.
- **Materials Discovery, Design, and Synthesis**—Developing novel synthesis strategies to design and precisely assemble structures in order to control materials properties, enabling discovery of new materials with unprecedented functionalities.

The portfolio emphasizes understanding of how to direct and control energy flow in materials systems over multiple time and length scales, with increasing emphasis on the mesoscale. The research will enable prediction of materials behavior, transformations, and processes in challenging real-world systems—for example, for materials with many atomic constituents, complex structures, and a broad range of defects that are exposed to extreme environments. To maintain leadership in materials discovery, the research explores new frontiers and unpredicted, emergent materials behavior in materials systems, utilization of nanoscale control, and systems that are metastable or far from equilibrium. Finally, the research includes investigation of the interfaces between physical and biological sciences to explore bio-mimetic processes as new approaches to novel materials design. This subprogram is also the home of the DOE Experimental Program to Stimulate Competitive Research (EPSCoR) that supports research spanning the broad range of DOE's science and technology programs in states that have historically received relatively less Federal research funding in the university sector.

In addition to single-investigator and small-group research, the subprogram supports EFRCs and the Batteries and Energy Storage Energy Innovation Hub. These research modalities support multi-investigator, multidisciplinary research and focus on forefront energy technology challenges. The EFRCs support teams of investigators to perform basic research to accelerate transformative solutions for a wide range of energy technologies. The Batteries and Energy Storage Hub supports a large, tightly integrated team and research that spans basic and applied regimes with the goal of providing the scientific understanding that will enable the next generation of electrochemical energy storage for vehicles and the electrical grid. A new activity proposed for FY 2015 will support integrated, multidisciplinary teams of theorists and experimentalists that will focus on computational materials science to develop validated community codes for predictive design of functional materials. This activity will also support new approaches that enhance the use of the large data sets derived from advanced materials characterization of materials synthesis, processing, and properties assessments and the parallel data that are generated by large scale computational efforts on theory and modeling of materials phenomena.

Scattering and Instrumentation Sciences Research

Advanced characterization tools with very high precision in space and time are essential to understand, predict, and ultimately control matter and energy at the electronic, atomic, and molecular levels. These capabilities provide the foundation for research central to DOE missions in energy, environment, and national security. Research in Scattering and Instrumentation Science supports innovative science, techniques, and instrumentation for scattering, spectroscopy, and imaging using electrons, neutrons, and x-rays. These tools provide precise information on the atomic structure and dynamics in materials. DOE's longstanding investments in world-leading electron, neutron, and synchrotron x-ray scattering facilities and the large associated user communities are a testament to the importance of this activity to the DOE mission. Revolutionary advances in these techniques will enable transformational research on advanced materials to address energy challenges.

The unique interactions of electrons, neutrons and x-rays with matter enable a range of complementary tools with different sensitivities and resolution for the characterization of materials at length- and time-scales spanning several orders of magnitude. Recent advances in investigations of dynamic phenomena in real-time and relevant conditions provide a window into material functions under the conditions in which the materials are used. New instrumentation in the ultrafast regime will be used to investigate dynamics at very fast timescales related to electronic, catalytic, magnetic, and other transport processes. A distinct aspect of this activity is the development of innovative instrumentation concepts and techniques for neutron scattering and imaging needed to correlate the microscopic and macroscopic properties of energy materials. Characterization for mesoscale phenomena are growing aspects of this research.

Condensed Matter and Materials Physics Research

Understanding the foundations of how to control and change the properties of materials is critical to improving their functionality on every level and is essential to fulfilling DOE's energy mission. The Condensed Matter and Materials Physics activity supports experimental and theoretical research to advance our current understanding of phenomena in condensed matter—solids with structures that vary in size from the nanoscale to the mesoscale, the materials that make-up the infrastructure for energy technologies, including electronic, magnetic, optical, thermal, and structural materials.

A central focus is research to characterize and understand materials whose properties are derived from the strong interactions of the electrons in their structure, such as superconductors and magnetic materials. An emphasis is placed on investigating low-dimensional systems, including nanostructures, and studies of the electronic properties of materials under extreme conditions such as ultra-low temperatures and extremely high magnetic fields. The research is relevant to energy technologies and advances the fundamental understanding of the elementary energy conversion steps related to photovoltaics and solid state lighting, the energetics of hydrogen storage, and electron spin-phenomena and basic semiconductor physics relevant to next generation information technologies and electronics. Fundamental studies of the quantum mechanical behavior of electrons in materials will lead to an improved understanding of electrical and thermal conduction in a wide range of material systems. There is a critical need to couple theories that describe properties at the atomic scale to properties at the macroscale where the influence of size, shape, and composition is not adequately understood.

The activity also emphasizes understanding how materials respond to their environments, including temperature, electromagnetic fields, radiation, and chemical environments. This includes the defects in materials and their effects on materials' electronic properties, strength, structure, deformation, and failure over a wide range of length and time scales that will enable the design of materials with superior properties and resistance to change under the influence of radiation.

Materials Discovery, Design, and Synthesis Research

The discovery and development of new materials has long been recognized as the engine that drives science frontiers and technology innovations. Predictive discovery of new forms of matter with tailored properties is still a significant challenge for materials sciences. A strong, vibrant research enterprise in the discovery of new materials is critical to world leadership—scientifically, technologically and economically. One of the goals of this activity is to grow and maintain U.S.

leadership in materials discovery by investing in advanced synthesis capabilities and by coupling these with state-of-the-art user facilities and advanced computational capabilities at DOE national laboratories.

A key part of this portfolio is bio-mimetic and bio-inspired materials research—translating biological processes into impactful approaches to the design and synthesis of materials with the remarkable properties found in nature, e.g., self-repair and adaptability to the changing environment. Synthesis science and materials chemistry research underpin many energy-related technological areas such as batteries and fuel cells, catalysis, solar energy conversion and storage, friction and lubrication, and membranes for advanced separations, efficient ion transport and highly selective gas separation and storage.

Major research directions include the controlled synthesis of nanoscale materials and their assembly into functional materials with desired properties; porous materials with tailored reactivities and porosities; mimicking the energy-efficient synthesis approaches of biology to generate new, advanced materials for use under harsher, non-biological conditions; bio-inspired materials that assemble autonomously and, in response to external stimuli, dynamically assemble and disassemble; and adaptive and resilient materials that also possess self-repairing capabilities. Synthesis science supports fundamental research on the development of new methods and techniques to synthesize materials with targeted structure and properties. An important element of this activity is the development of real-time monitoring tools, diagnostic techniques, and instrumentation that can provide information on the progression of structure and properties as a material is formed, in order to understand the underlying physical mechanisms and to gain atomic level control of material synthesis and processing.

<u>Experimental Program to Stimulate Competitive Research (EPSCoR)</u>

DOE's Experimental Program to Stimulate Competitive Research (EPSCoR) is a Federal-State partnership program designed to enhance the capabilities and research infrastructure of designated states and territories to conduct sustainable and nationally competitive research. This activity supports basic research spanning the broad range of science and technology related to DOE mission areas in states and territories that have historically received relatively less Federal research funding than other states. EPSCoR helps these states develop their capabilities so that they can successfully compete for research funding. The EPSCoR program supports materials sciences, chemical sciences, physics, energy-relevant biological sciences, geological and environmental sciences, high energy physics, nuclear physics, fusion energy sciences, advanced computing, and the basic sciences underpinning fossil energy, electricity delivery and reliability, nuclear energy, and energy efficiency and renewable energy.

EPSCoR promotes strong research collaboration between scientists/engineers in the designated states/territories and the world-class national laboratories, leveraging national user facilities and taking advantage of opportunities for intellectual collaboration across the DOE system. DOE EPSCoR supports Implementation Grants (large grants that promote development of infrastructure and research teams) and State-Laboratory partnership grants (individual university-based principal investigators teaming with national laboratories). EPSCoR is science-driven and supports the most meritorious proposals based on peer review and programmatic priorities.

<u>Energy Frontier Research Centers (EFRCs)</u>

The EFRCs, initiated as five-year awards in FY 2009 and undergoing a full recompetition in FY 2014, are a unique and important research modality, bringing together the skills and talents of teams of investigators to perform energy-relevant, basic research with a scope and complexity beyond that possible in standard single-investigator or small-group awards. These multi-investigator, multi-disciplinary centers foster, encourage, and accelerate basic research to provide the basis for transformative energy technologies. The EFRCs are funded on a continuing basis through annual appropriations through this subprogram and the Chemical Sciences, Geosciences, and Biosciences subprogram. The EFRCs supported in this subprogram are focused on: the design, discovery, synthesis, and characterization of novel, solid-state materials that improve the conversion of solar energy and heat into electricity and fuels and that enhance the conversion of electricity to light; the development of the understanding of materials and processes required to enable improved electrical energy storage and to increase materials resistance to corrosion, decay, or failure in extreme conditions of temperature, pressure, radiation, or chemical exposures; and the exploration of emergent phenomena, such as superconductivity, that can optimize energy flow and boost the efficiency of energy transmission. At the end of FY 2013, after four years of research activity, the 46 EFRCs had produced an impressive breadth of accomplishments, including over 4,000 peer-reviewed journal papers, over 200 patent applications and over 90 additional patent/invention disclosures.

BES's active management of the EFRCs continues to be an important feature of the program. A variety of methods are used to regularly assess the progress of the EFRCs, including annual progress reports, monthly phone calls with the EFRC Directors, periodic Directors' meetings, and on-site visits by program managers. BES also conducts in-person reviews by outside experts. Each EFRC undergoes a review of its management structure and approach in the first year of the award and a midterm assessment of scientific program and progress compared to its 5-year scientific goals. To facilitate communication of results to other EFRCs and interactions with DOE technology programs, meetings of the EFRC principal investigators are held on an approximately biennial frequency.

An open recompetition of the EFRC program is taking place in FY 2014. New and renewed EFRCs will be selected based on peer review by external experts. All of the EFRCs will continue to emphasize both grand challenge science and energy use-inspired research. Compared to the original awards, these EFRCs will include topics in mesoscale science and an enhanced focus on predictive materials and chemical sciences. Another change is that these will be 3-year initial awards with the extension for the remaining 2-years of the 5-year period dependent on the outcome of the mid-term peer review. This change will allow optimization of the portfolio at the midterm assessment, bolstering the strongest performers and eliminating the weakest performing activities as appropriate. In FY 2015, the EFRCs awarded in FY 2014 will undergo a peer review to ensure a strong start-up of their research programs and to provide a critical assessment of their management structures.

Energy Innovation Hubs (Batteries and Energy Storage)

Advanced energy storage solutions have become increasingly critical to the Nation with the expanded deployment of renewable energy sources coupled with growth in the numbers of hybrid and electric vehicles. For the electric grid, new approaches to electrochemical energy storage can provide enhanced grid stability and enable intermittent renewable energy sources to meet continuous electricity demand. For vehicles, new batteries with improved lifetimes, safety, and storage capacity are needed to expand the range of electric vehicles from a single charge while simultaneously decreasing the volume, manufacturing cost and weight. Today's electrical energy storage approaches suffer from limited energy and power capacities, lower-than-desired rates of charge and discharge, life-cycle limitations, low abuse tolerance, high cost, and decreased performance at high or low temperatures.

The Batteries and Energy Storage Hub, established in December 2012, focuses on understanding the fundamental performance limitations for electrochemical energy storage to launch the next generation, beyond lithium-ion energy storage technologies relevant to both the electric grid and transportation. The Hub, the Joint Center for Energy Storage Research (JCESR), is led by Argonne National Laboratory joined by four other national laboratories, five universities, and four industrial partners. JCESR's core task is basic research—using a new generation of nanoscience tools that enable observation, characterization, and control of matter down to the atomic and molecular scales to understand materials and chemical processes that are at the core of battery performance. The participation of industrial partners will facilitate efforts to ensure that the outcome of basic research leads toward practical solutions that are competitive in the marketplace.

JCESR focuses on systems beyond lithium-ion and discovery of new energy storage chemistries through the development of an atomic-level understanding of reaction pathways and development of universal design rules for electrolyte function. The overarching goals driving the scientific and engineering research towards next-generation energy storage technologies are summarized by JCESR as 5/5/5—five times the energy density of current systems at one-fifth the cost within five years, the award period for the Hub. In addition, JCESR will deliver two additional legacies to the broader energy storage community: creation of a library of fundamental scientific knowledge of the phenomena and materials of energy storage at the atomic and molecular level and demonstration of a new paradigm for battery R&D—integrating discovery science, battery design and computation, and research prototyping in a single highly interactive organization. Success in achieving these legacies will be measured by the rate, quality, and impact of JCESR's scientific publications, patents, and interactions across its discovery science, battery design and computation, and research prototyping functions. Progress against milestones is evaluated by quarterly/annual reports and annual performance reviews by external panels of science and management experts to verify and validate performance.

Computational Materials Sciences

Recent major strides in materials synthesis, processing, and characterization, combined with concurrent advances in computational science—enabled by improvements in high performance computing capabilities—have opened an unprecedented opportunity to design new materials with specific properties. The opportunity is to leap beyond simple extensions of current theory and models of materials towards a paradigm shift in which specialized computational codes and software enable the ability to design, discover, and develop new materials, and in turn, create new advanced, innovative technologies. Given the importance of materials to virtually all technologies, computational materials sciences is a critical area in which the United States needs to be competitive.

If successful, this paradigm shift would significantly accelerate the design of revolutionary materials to meet the Nation's energy goals and enhance economic competitiveness. Development of fundamentally new design principles could enable stand-alone research codes and software packages to address multiple length and time scales for prediction of the total functionality of materials over a lifetime of use. Recent scientific workshops and National Research Council studies have identified enticing scientific challenges that would advance these goals.[a] Examples include dynamics and strongly correlated matter, conversion of solar energy to electricity, design of new catalysts for a wide range of industrial uses, and transport in materials for improved electronics. Success will require extensive research and development with the goal of creating experimentally validated, robust community codes that will enable functional materials innovation.

Research and development to create the computational codes will require a fully integrated team approach, combining the skills of experts in materials theory, modeling, computation, synthesis, characterization, and processing/fabrication. The range of the research will include development of new ab initio theory, mining the data from both experimental and theoretical databases, performing advanced in situ/in operando characterization to generate the specific parameters needed for computational models, and well controlled synthesis to confirm the predictions of the codes. Many of the underlying phenomena require understanding the material dynamics at ultrafast time scales and with near atomic resolution—requiring effective use of the unique world leading tools and instruments at DOE's user facilities, from ultrafast free electron lasers to aberration corrected electron microscopes to the best tools for atomically controlled synthesis.

To facilitate U.S. leadership in this competitive field, FY 2015 funding is requested to support up to four large teams of scientists and engineers who would perform the basic research and develop and deliver codes and associated experimental/computational data for the design of functional materials. Each team would focus on a different area of functional materials; BES-led coordination among the teams would further leverage activities and accelerate key foundational research. A Funding Opportunity Announcement would solicit proposals from the materials research community, with the best proposals selected by peer review. Awards would be for five years, with the first year funded with FY 2015 funding. An ideal end product would be open source, robust, validated, user friendly software that captures the essential physics and chemistry of relevant systems and can be used by the broader research community and by industry to dramatically accelerate the design of new functional materials. Following the effective management approach employed with other large team research activities, BES will actively manage the project through annual peer reviews to assess progress towards planned scientific goals.

[a] U.S. DOE. *Computational Materials Science and Chemistry for Innovation*. U.S. Department of Energy Office of Science, 2010. National Research Council. Integrated Computational Materials Engineering: A Transformational Discipline for Improved Competitiveness and National Security. Washington, DC: The National Academies Press, 2008.

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Scattering and Instrumentation Sciences Research		
Research continues to emphasize the opportunities afforded by x-ray, neutron and electron scattering, spectroscopy, and imaging for the development of new functional materials for energy production, storage, and distribution. Scattering science enables unique insights into the structure and dynamics of new energy materials over relevant time and length scales. Research advances the development and utilization of new capabilities with increasing physical, chemical, structural, and temporal precision for materials research. Research on soft and hybrid materials is emphasized. New research advances the use of ultrafast techniques to tackle research challenges in materials sciences.	Time domain, energy spectroscopy, and *in situ* instrumentation continues to improve, allowing advanced investigations of excitation and transport with high spatial resolution across relevant length scales for energy systems. Integration of multiple sources and detection schemes will be emphasized to provide more complete assessment of spatial structures and excitation levels with high time resolution. Quantitative pictures of complex materials as they evolve in time under realistic environmental boundary conditions will validate theory and increase phenomenological understanding. Spatial resolution will span atoms to microstructure, including the mesoscale. Time scales to be investigated involve electronic motion in the ultra-fast regime, cooperative modes at atomic vibration and diffusion time scales, and degradation time scales across mesoscale structures.	Research support is flat compared to FY 2014. Areas of increased emphasis include ultrafast materials science, in situ, under operational conditions, time-resolved imaging, and energy excitation spectroscopy with high spatial resolution; all directed towards understanding scientific phenomena on real systems at realistic operating conditions. Mature use of recently established techniques (such as high pressure cell studies and metallurgical orientational imaging) will be de-emphasized as these are now being implemented more routinely by researchers investigating particular materials systems.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Condensed Matter and Materials Physics Research		
Research continues to emphasize experimental and theoretical research on materials that exhibit correlation effects, including new phenomena observed in topological surface states and the development of new theoretical tools and validated software for materials discovery that is relevant to energy technologies. Research focuses on advancing fundamental understanding of defects in materials, which is needed to extend the lifetime and enhance the performance of materials used in energy generation and energy end-use technologies. This activity supports research on large, ultra-cold atom clusters that can exhibit both bosonic or ferminoic behavior to provide new insights into the evolution of condensed matter behavior. There is continued support for research on understanding structure-property relationships in materials by studying the influence of reduced dimensionality and defects on the physical, optical, and electrical properties of materials; and controlling material functionality in response to external stimuli such as temperature, pressure, magnetic and electric fields, and radiation.	Research will continue to support experimental and theoretical materials research emphasizing correlation effects, including phenomena observed in topological surface states. The program will emphasize the development of understanding of matter at atomistic length scales expanding to include properties at the mesoscale. This includes research on cold atom clusters to determine if these systems can provide new insights into the evolution of condensed matter behavior from atomic constituents. The program supports research on phenomena that occur as a consequence of interfaces and reduced dimensionality. Research will continue to include assessments of the phenomena related to the structural, optical, and electrical properties of materials; and the control of material functionality in response to external stimuli including temperature, pressure, magnetic and electric fields, and radiation. The program will continue to grow research on new theoretical tools and validated software for materials discovery. The research will continue to advance fundamental understanding of defects to extend the lifetime and enhance performance of materials in energy generation and energy end-use applications.	Research support is flat compared to FY 2014. The FY 2015 program enhances research on predictive materials design and experimental validation. The program will also expand research focused on our understanding of matter at atomistic length scales expanding to include properties at the mesoscale. Research on granular materials and conventional superconductivity will be de-emphasized.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Materials Discovery, Design, and Synthesis Research		
Research continues on the development of guiding principles for the predictive design and synthesis of materials across multiple length scales—from atomic and molecular to nanoscale to mesoscale and ultimately to bulk. Predictive design of materials synthesis is coupled to experimental research on biology-inspired, physical, and chemical synthesis and processing techniques. This is made possible by effective integration of theory and experiment, modeling of synthetic pathways and experimental designs. Synthesis pathways may be precisely controlled by the use of in situ diagnostic tools and will pave the way for atom- and energy-efficient syntheses of new forms of matter with tailored properties. Research on understanding of carbon capture takes advantage of novel chemistries and approaches for gas storage and release, including innovative biomolecular materials research.	Research will continue to focus on the predictive design and synthesis of materials across multiple length scales, with a particular emphasis on the mesoscale. This will be enabled by more effective coupling of computational tools to experimental research on biology-inspired, physical, and chemical synthesis and processing techniques. Synthesis pathways may be better understood and precisely controlled by use of in situ diagnostic tools and characterization techniques, developed in the laboratory and at BES user facilities. This will create viable approaches for atom- and energy-efficient syntheses of new forms of matter with tailored properties. A key challenge will be to realize the complexity and functionality of biological systems, but with the use of inorganic earth-abundant materials. Research on novel materials for gas separations and storage will continue to take advantage of novel chemistries and concepts, including those inspired by biology.	Research support is flat compared to FY 2014. Research on developing synthesis methods for nanomaterials, e.g., nanoparticles, nanorods, etc. will be deemphasized in view of the recent progress on these topics. Research related to mesoscale phenomena and the building of mesoscale structures from nanoscale building blocks will be enhanced.
Experimental Program to Stimulate Competitive Research (EPSCoR)		
Efforts continue to span science in support of the DOE mission, with continued emphasis on science that underpins DOE energy technology programs. Meritorious Office of Science Early Career Research Program proposals from EPSCoR jurisdictions will be considered for support on a case-by-case basis. Funding for implementation grants is enhanced to minimize mortgages.	Research strengthens capabilities to advance DOE mission needs across energy science and technology in the EPSCoR states. Implementation grant and investment in early career research staff from EPSCoR states will be sustained.	Research support decreases compared to FY 2014. The additional funding provided in FY 2014 was used to support implementation grants with funding profiles that minimized outyear mortgages.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Energy Frontier Research Centers (EFRCs)		
A single Funding Opportunity Announcement (FOA) was issued for both renewal and new EFRCs for five-year awards beginning in FY 2014. The EFRC FOA encouraged the formation of effective teams to address the broad range of fundamental science needed to power transformative energy technologies, including newly identified opportunities in the computational design of materials and chemical processes and mesoscale science. All current EFRCs, including those initially funded through ARRA, had the opportunity to compete for a second five-year performance period. All awards, both new and renewal, will be based on rigorous peer review of the research proposed for the five year award term. Applicants requesting renewal funding will also be assessed on progress during the first five-year award.	The EFRCs that will be started in FY 2014 will perform the first year of research of the award period as outlined in their proposals. This multidisciplinary research will continue to provide accelerated progress in fundamental, energy-use inspired research. The research in these new EFRCs includes investigations of mesoscale science and utilization of computational research to predictably design new materials and processes. BES will hold a peer review to assess management and early operations.	FY 2015 support for EFRCs will continue at the FY 2014 level.
Energy Innovation Hubs—Batteries and Energy Storage		
Hub research on electrochemical energy storage continues to follow the plans established in the proposal as revised in the initial months of operation in consultation with DOE. Joint Center for Energy Storage Research (JCESR) operations and management processes are informed by the management review held in October 2013. A full peer review of the technical progress of the Hub research is scheduled for July 2014.	Research will continue to follow the established project plan for thrusts on multivalent intercalation, chemical transformations, and non-aqueous redox flow, as well as cross-cutting research on materials characterization, theory, and modeling. Systems analysis and translation activities will include techno-economic modeling, cell design, and preliminary prototype development. Research will include a focus on the electrolyte genome, demonstrating the utility of this computational framework for designing new electrolytes using structure-chemical trends extracted from >10,000 first-principles calculated molecular motifs, modifications and mutations.	The funding is approximately flat compared to FY 2014, following the planned funding profile.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Computational Materials Science		
	Coupling today's computational capabilities with world leading experimental instrumentation, Computational Materials Science will enhance U.S. leadership in the development of experimentally validated, robust computational codes that will enable materials discovery and innovation to meet the Nation's energy goals and enhance economic competitiveness. Funding will support up to four large teams of experts in materials theory, modeling, computation, synthesis, characterization, and processing/fabrication to perform the basic research required to develop and deliver research-oriented software and associated databases for predictive design of functional materials. In FY 2015, a competitive, peer review process will select the best research proposals, with each of the selected proposal teams focused on a different type of functional material. FY 2015 funding will support the first year of 5-year awards.	This is a new research activity for FY 2015. Areas of research opportunity have been identified by BES and other agency workshops and National Research Council studies. Potential research areas relevant to energy include dynamics and strongly correlated matter (magnets, superconductors), conversion of solar energy to electricity, transport in materials for improved electronics, and design of new catalysts. Unique to this new activity are the breadth of the theory-computation-experimental teams and the specific goal of delivering software open source packages and associated databases to address multiple length and time scales for discovery and prediction of the functionality of materials for energy applications.

Basic Energy Sciences
Chemical Sciences, Geosciences, and Biosciences

Description

The transformation of energy between types (optical, electrical, chemical, heat, etc.) and the rearrangement of matter at the atomic, molecular, and nano-scales are critically important in every energy technology. The *Chemical Sciences, Geosciences, and Biosciences* subprogram supports research that explores fundamental aspects of chemical reactivity and energy transduction in order to develop a broad spectrum of new chemical processes, such as catalysis, that can contribute significantly to the advancement of new energy technologies. Research addresses the challenge of understanding physical and chemical phenomena over a tremendous range of spatial and temporal scales, from molecular through nanoscale and on to mesoscale, and at multiple levels of complexity, including the transition from quantum to classical behavior.

At the heart of this research lies the quest to understand and control chemical processes and the transformation of energy at the molecular scale in systems spanning simple atoms and molecules, active catalysts, and larger biochemical or geochemical systems. At the most fundamental level, the development and understanding of the quantum mechanical behavior of electrons, atoms, and molecules is rapidly evolving into the ability to control and direct such behavior to achieve desired results in meso- and macro-scale energy conversion systems.

This subprogram seeks to extend this new era of control science to include the capability to tailor chemical transformations with atomic and molecular precision. Here, the challenge is to achieve fully predictive assembly and manipulation of larger, more complex chemical, geochemical, and biochemical systems at the same level of detail now known for simple molecular systems.

To address these challenges, the portfolio includes coordinated research activities in three areas:

- **Fundamental Interactions**—Structural and dynamical studies of atoms, molecules, and nanostructures with the aim of providing a complete understanding of atomic and molecular interactions in the gas phase, condensed phase, and at interfaces.
- **Chemical Transformations**—Design, synthesis, characterization, and optimization of chemical processes that underpin advanced energy technologies, including catalytic production of fuels, nuclear energy, and geological sequestration of carbon dioxide.
- **Photochemistry and Biochemistry**—Research on the molecular mechanisms involved in the capture of light energy and its conversion into chemical and electrical energy through biological and chemical pathways.

The portfolio of this subprogram includes several unique efforts that enable these overall research themes. Novel sources of photons, electrons, and ions are developed to probe and control atomic, molecular, nanoscale, and mesoscale matter, particularly ultrafast optical and x-ray techniques to study and direct molecular, dynamics, and chemical reactions. This subprogram supports the nation's largest Federal effort in catalysis science for the design of new catalytic methods and materials for the clean and efficient production of fuels and chemicals. It also contains a unique effort in the fundamental chemistry of the heavy elements, with complementary research on chemical separations and analysis. Research in geosciences emphasizes analytical and physical geochemistry, rock-fluid interactions, and flow/transport phenomena that are critical to a scientific understanding of carbon sequestration. Natural photosynthetic systems are studied to create robust artificial and bio-hybrid systems that exhibit the biological traits of self-assembly, regulation, and self-repair. Complementary research on artificial systems includes organic and inorganic photochemistry, photo-induced electron and energy transfer, photoelectrochemistry, and molecular assemblies for artificial photosynthesis.

In addition to single-investigator and small-group research, the subprogram supports EFRCs and the Fuels from Sunlight Energy Innovation Hub. These research modalities support multi-investigator, multidisciplinary research and focus on forefront energy technology challenges. The Hub supports a large, tightly integrated team and research that spans basic and applied regimes with the goal of providing the scientific understanding that will enable the next generation of technologies for the direct conversion of sunlight to chemical fuels.

Fundamental Interactions Research

This activity builds the fundamental science basis essential for technological advances in a diverse range of energy processes. Research encompasses structural and dynamical studies of atoms, molecules, and nanostructures, and the description of their interactions in full quantum detail. The ultimate objective, often gained through studies of model systems, is a complete understanding of reactive chemistry in the gas phase, condensed phase, and at interfaces. In complement, this activity supports development of novel experimental and theoretical tools. New sources of photons, electrons, and ions are used to probe and control atomic, molecular, nanoscale, and mesoscale matter and processes on ultrafast time scales. New algorithms for computational chemistry are developed and applied in close coordination with experiment. Areas of emphasis are use-inspired, with relevance, for example, to combustion and catalysis, but the knowledge and techniques produced by this activity form a science base to underpin numerous aspects of the DOE mission.

The principal research thrusts are in atomic, molecular, and optical (AMO) sciences and chemical physics. AMO research emphasizes the interactions of atoms, molecules, and nanostructures with photons, particularly those from BES light sources, to characterize and control their behavior. AMO research examines energy transfer within isolated molecules that provides the foundation for understanding the making and breaking of chemical bonds. Chemical physics research builds from the AMO research foundation by examining reactive chemistry of molecules that are not isolated, but whose chemistry is profoundly affected by the environment. It explores the transition from molecular-scale chemistry to collective phenomena in complex systems, such as the effects of solvation or interfaces on chemical structure and reactivity. This transition is often accompanied by a parallel transition from quantum mechanical behavior to classical or continuum behavior. Understanding such collective behavior is critical in a wide range of energy and environmental applications, from solar energy conversion to improved methods for handling radiolytic effects in context of advanced nuclear fuel or waste remediation. Gas-phase chemical physics emphasizes the incredibly rich chemistry of combustion—burning diesel fuel involves thousands of chemical reactions and hundreds of distinct species. Combustion simulation and diagnostic studies address the subtle interplay between combustion chemistry and the turbulent flow that characterizes all real combustion devices. This activity includes support for the Combustion Research Facility, a multi-investigator research laboratory at the Sandia National Laboratories campus in Livermore, California, for the study of combustion science.

Chemical Transformations Research

Chemical Transformation Research emphasizes the design, synthesis, characterization, and optimization of chemical processes that underpin advanced energy technologies including the catalytic production of fuels, nuclear energy, and geological sequestration of carbon dioxide. A tremendous breadth of novel chemistry is covered: inorganic, organic, and hybrid molecular complexes; nanostructured surfaces; electrochemistry; nanoscale membranes; bio-inspired chemistry; and analytical and physical geochemistry. This activity develops unique tools for chemical analysis, using laser-based and ionization techniques for molecular detection, with an emphasis on imaging chemically distinct species.

This activity has a leadership role in the application of basic science to unravel the principles that define how catalysts work—how they accelerate and direct chemistry. Such knowledge enables the rational synthesis of novel catalysts, designed at the nanoscale but operating at the mesoscale, which will lead to increased energy efficiency and chemical selectivity. Because so many processes for the production of fuels and chemicals rely on catalysts, improving catalytic efficiency and selectivity has enormous economic and energy consequences. Advanced gas separation schemes for the removal of carbon dioxide from post-combustion streams are explored—these are essential to making carbon capture an economic reality. Fundamental studies of the structure and reactivity of actinide-containing molecules provides the basis for their potential use in advanced nuclear energy systems. Geosciences research emphasizes a greater understanding of the consequences of deliberate storage, or accidental discharges, of energy related products (carbon dioxide or waste effluents), which require ever more refined knowledge of how such species react and move in the subsurface environment.

Photochemistry and Biochemistry Research

This activity supports research on the molecular mechanisms that capture light energy and convert it into electrical and chemical energy in both natural and man-made systems. The work is of critical importance for the effective use of our most abundant and durable energy source—the sun. More energy from the sun strikes the earth in one hour than is used by its entire human population in a year.

Natural photosynthesis is studied to provide roadmaps for the creation of robust artificial and bio-hybrid systems that exhibit the biological traits of self-assembly, regulation, and self-repair and that span from the atomic scale through the mesoscale. Physical science tools are extensively utilized to elucidate the molecular and chemical mechanisms of biological energy transduction, including processes beyond primary photosynthesis such as carbon dioxide reduction and subsequent deposition of the reduced carbon into energy-dense carbohydrates and lipids. Complementary research on artificial systems encompasses organic and inorganic photochemistry, light-driven energy and electron transfer processes, as well as photo-electrochemical mechanisms and molecular assemblies for artificial photosynthetic fuel production.

Energy Frontier Research Centers

The EFRCs, initiated as five-year awards in FY 2009 and undergoing a full recompetition in FY 2014, are a unique and important research modality, bringing together the skills and talents of teams of investigators to perform energy-relevant, basic research with a scope and complexity beyond that possible in standard single-investigator or small-group awards. These multi-investigator, multi-disciplinary centers foster, encourage, and accelerate basic research to provide the basis for transformative energy technologies. The EFRCs are funded on a continuing basis through annual appropriations through this subprogram and the Materials Sciences and Engineering subprogram. The EFRCs supported in this subprogram are focused on the design, discovery, control, and characterization of the chemical, biochemical, and geological moieties and processes for the advanced conversion of solar energy into chemical fuels; for improved electrochemical storage of energy; for the creation of next-generation biofuels via catalytic chemistry and biochemistry; for the clean and efficient combustion of advanced transportation fuels; and for science-based carbon capture and geological sequestration. At the end of FY 2013, after four years of research activity, the 46 EFRCs had produced an impressive breadth of accomplishments, including over 4,000 peer-reviewed journal papers, over 200 patent applications and over 90 additional patent/invention disclosures.

BES's active management of the EFRCs continues to be an important feature of the program. A variety of methods are used to regularly assess the progress of the EFRCs, including annual progress reports, monthly phone calls with the EFRC Directors, periodic Directors' meetings, and on-site visits by program managers. BES also conducts in-person reviews by outside experts. Each EFRC undergoes a review of its management structure and approach in the first year of the award and a midterm assessment of scientific program and progress compared to its 5-year scientific goals. To facilitate communication of results to other EFRCs and interactions with DOE technology programs, meetings of the EFRC principal investigators are held on an approximately biennial frequency.

An open recompetition of the EFRC program is taking place in FY 2014. Renewing and new EFRCs will be selected based on peer review by external experts. All of the EFRCs will continue to emphasize both grand challenge science and energy use-inspired research. Compared to the original awards, these EFRCs will include topics in mesoscale science and an enhanced focus on predictive materials and chemical sciences. Another change is that these will be 3-year initial awards with the extension for the remaining 2-years of the 5-year period dependent on the outcome of the mid-term peer review. This change will allow optimization of the portfolio at the midterm assessment, bolstering the strongest performers and eliminating the weakest performing activities as appropriate. In FY 2015, the EFRCs awarded in FY 2014 will undergo a peer review to ensure a strong start-up of their research programs and to provide a critical assessment of their management structures.

Energy Innovation Hubs—Fuels from Sunlight

Solar energy is a significant yet largely untapped clean energy resource. More energy from the sun strikes the earth in one hour than is consumed by all humans on the planet in a year. Through the process of photosynthesis, plants can effectively convert energy from the sun into energy-rich chemical fuels using the abundant feedstocks of water and carbon dioxide. If a human-made artificial photosynthesis system can be developed that can generate usable fuels directly from sunlight, carbon dioxide, and water, the potential energy benefits for the Nation would be substantial, reducing dependence on fossil fuels through use of fuels generated directly by sunlight. Due to the significant scientific and engineering challenges associated with developing such a system, however, there are no commercially-available fuels generated via artificial photosynthesis. For this reason, the Basic Energy Sciences Advisory Committee report, New Science for Secure and Sustainable Energy Future,[a] listed the production of fuels directly from sunlight as one of three strategic goals for which transformational science breakthroughs are most urgently needed.

Established in September 2010, the Fuels from Sunlight Hub, the Joint Center for Artificial Photosynthesis (JCAP), is a multi-disciplinary, multi-investigator, multi-institutional effort to create critical transformative advances in the development of artificial photosynthetic systems for converting sunlight, water, and carbon dioxide into a range of commercially useful fuels. The Hub is targeted towards understanding and designing catalytic complexes or solids that generate chemical fuel from carbon dioxide and/or water; integrating all essential elements, from light capture to fuel formation components, into an effective solar fuel generation system; and providing a pragmatic evaluation of the solar fuel system under development. JCAP is led by the California Institute of Technology (Caltech) in primary partnership with Lawrence Berkeley National Laboratory (LBNL). Other partners include the SLAC National Accelerator Laboratory and several University of California institutions. JCAP is composed of internationally renowned scientists and engineers who seek to integrate decades of research community efforts and address critical research and development gaps; its visionary goal is the construction of an artificial photosynthetic system for robustly producing fuel from the sun ten times more efficiently than current crops.

Research in JCAP ranges from fundamental discovery of new materials to science-based design and testing of fully functional prototypes. JCAP has eight major parallel research and development projects: light capture and conversion; heterogeneous catalysis; molecular catalysis; high throughput experimentation; catalyst and photochemical benchmarking; molecular-nanoscale interfaces; membrane and mesoscale assembly; and prototyping. The projects' efforts are synergistically split between JCAP-South on the campus of CalTech and JCAP-North located near LBNL, with the exception of the benchmarking and high-throughput experimentation projects that are consolidated at JCAP-South. JCAP also makes use of state-of-the-art facilities at LBNL and SLAC as part of their efforts to examine, understand, and manipulate matter at the nanoscale. Despite the different geographic locations, JCAP is designed to operate as a single scientific entity. Its current efforts consist of discovery research to identify robust, Earth-abundant light absorbers, catalysts, linkers, and membranes that are required components of a complete system and scale-up science for design and development of prototypes. By studying the science of scale-up and by benchmarking both components (catalysts) and systems (device prototypes), JCAP seeks to move bench-top discovery to proof-of-concept prototyping and thus accelerate the transition from laboratory discovery to industrial use.

The Fuels from Sunlight Hub receives the final year of funding of its initial five-year award term at the planned level in FY 2014. A decision for continued funding beyond the initial term, which ends in September 2015, will be made in FY 2015.

<u>General Plant Projects (GPP)</u>

GPP funding is provided for minor new construction, for other capital alterations and additions, and for improvements to land, buildings, and utility systems at the Ames Laboratory. Funding of this type is essential for maintaining the productivity and usefulness of Department-owned facilities and for meeting requirements for safe and reliable facilities operation. The total estimated cost of each GPP project will not exceed $10,000,000.

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[a] U.S. DOE Basic Energy Sciences Advisory Committee. *New Science for Secure and Sustainable Energy Future*. U.S. Department of Energy Office of Science, 2008.

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Fundamental Interactions Research		
AMO sciences research continues to emphasize the development and application of forefront ultrafast x-ray and optical probes of matter, utilizing the Linac Coherent Light Source and BES synchrotron light sources, and new theoretical methods for the interpretation of ultrafast measurements. Increasing emphasis is being placed on novel x-ray probes of matter, including non-linear optical approaches and time-resolved imaging to take snapshots of complex chemical and biochemical phenomena, and to advance fundamental understanding. Computational chemistry is advancing improved methods for studying electronically excited states in molecules and extended mesoscale systems, which are critically important to the design of energy conversion processes and materials. Increasing emphasis is being placed on predictive modeling of chemical processes. Chemical physics research is emphasizing development of new theoretical and simulation techniques relevant to a wide variety of potential applications. Work is continuing on advanced combustion research to accelerate the predictive simulation of highly efficient and clean internal combustion engines.	Research will continue to develop and apply forefront ultrafast x-ray and optical probes of matter, utilizing the LCLS, BES synchrotron light sources, and table-top laser-based ultrafast light sources, all aimed to advance fundamental understanding. Concomitant advances in theoretical methods will be sought to guide and interpret ultrafast measurements and for predicting ultrafast phenomena. Increased emphasis will be placed on time-resolved x-ray probes of matter at unprecedented short time scales and in systems of substantial complexity. These will include non-linear x-ray phenomena, structural determinations for individual molecules and particles, and time-resolved imaging to record complex chemical and biochemical phenomena. Computational efforts will stress improved methods for electronically excited states in molecules and extended mesoscale systems, which are key to the efficient design of energy conversion processes and materials. Work will continue on advanced combustion research to accelerate the predictive simulation of highly efficient and clean internal combustion engines. Increased emphasis will be placed on investigating properties of combustion in high-pressure or multiphase systems.	Research support is flat compared to FY 2014. Efforts in predictive theory and modeling will be enhanced due to importance of such methods to guide and interpret increasingly complex measurements, and for predictive modeling of chemical processes. Studies of ultra cold molecules will be deemphasized and some well-developed research topics in molecular and particle spectroscopy may be redirected to evolving forefront areas.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Chemical Transformations Research		
Research is emphasizing the complementary development of computational methods for the simulation of photo-catalytic, fuel-forming reactions with efforts in synthesis and characterization of new catalytic materials that are designed at the nanoscale to function on the mesoscale. The catalytic conversion of biomass to fuels and other chemical products is a major emphasis. Novel approaches to the separation of carbon dioxide from post-combustion gas streams and oxygen from air prior to oxy-combustion and for research on the multi-scale dynamics of flow and plume migration in carbon sequestration, which can lead to improved models and risk assessment for carbon sequestration, are being explored. Actinide research in support of advanced nuclear energy systems is continuing, with emphasis on complex separation chemistry addressing the multiplicity of chemical forms and oxidation states in actinides for nuclear fuels and waste forms.	Research will continue in the development of computational and complementary synthesis and atomic-level characterization for discovery of catalytic mechanisms enabling design of materials at the nanoscale for new or enhanced photo-catalytic and fuel-forming chemistries. The catalytic conversion of biomass to fuels and other energy related chemical products will be emphasized. The discovery and design of novel separation approaches to carbon dioxide capture from post-combustion gas streams and oxygen from air prior to oxy-combustion will continue with added integration with computational methods. Research will continue on the multi-scale dynamics of reactive flow and plume migration in subsurface reservoirs, which can lead to improved models and risk assessment for carbon sequestration and other subsurface applications. Actinide research in support of advanced nuclear energy systems will continue, with emphasis on new insights in actinides chemical bonding enabling new chemistry for separation and related nuclear fuels and waste form processes. In support of the departmental emphasis on subsurface engineering, aspects of the separations and the geosciences portfolios will support new efforts in carbon capture and sequestration as well as research in geophysical characterization and monitoring techniques.	Research support is flat compared to FY 2014. Areas of increased emphasis include actinide chemical bonding and integration of computational and theoretical methods. Research in subsurface engineering complementary to applied efforts in the technology offices will be enhanced. Some mature areas of research in polymer synthesis, analytical mass spectrometry, and geophysics may be decreased.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Photochemistry and Biochemistry Research		
The development of computational methods for the simulation of light harvesting and conversion of solar energy into electricity and fuels is being emphasized (in coordination with the *Chemical Transformations* activity). Experimental research on direct conversion of solar energy to fuels and for advancing the catalytic conversion of biomass to fuels, both of which require translation from the nano to the mesoscale, is being supported. These include studies of the mechanisms that protect and self-repair the natural photosynthetic apparatus; photocatalytic generation of fuels in synthetic systems via semiconductor/polymer interfaces, dye-sensitized solar cells, inorganic-organic molecular complexes, and nano-scale water splitting assemblies; and advanced analysis of the structure of plant cell walls to elucidate catalytic routes for the conversion of biomass to fuels and other chemical products (in coordination with the *Chemical Transformations* activity).	Research on fundamental aspects of light energy capture and conversion in non-biological and biological (photosynthetic) systems will continue to be emphasized, providing a critical foundation for direct conversion of solar energy to electricity, fuels, and high-value chemicals. Enhanced support for computational and modeling studies will enable the design and fabrication of novel semiconductor/polymer interfaces, dye-sensitized solar cells, inorganic-organic molecular complexes, and biohybrid light harvesting complexes. Greater emphases on understanding the mechanisms of water-splitting, redox, and other energy-relevant biological (enzymatic) reactions, from the nano- to the mesoscale, will provide new insights important for development of novel bio-inspired catalysts based on earth-abundant materials, while biosynthetic and structural studies of the plant cell wall will help inform catalytic strategies for the direct conversion of biomass to fuels and other products.	Research support is flat compared to FY 2014. Research related to mesoscale phenomena in natural systems will be enhanced. Efforts in molecular solar thermal energy storage and solar energy conversion in artificial membranes will be deemphasized. Research on plant developmental and stress response mechanisms targeted towards biomass production may also be decreased.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Energy Frontier Research Centers (EFRCs)		
A single Funding Opportunity Announcement (FOA) was issued for both renewal and new EFRCs for 5-year awards beginning in FY 2014. The EFRC FOA encouraged the formation of effective teams to address the broad range of fundamental science needed to power transformative energy technologies, including newly identified opportunities in the computational design of materials and chemical processes and mesoscale science. All current EFRCs, including those initially through ARRA, had the opportunity to compete for a second five-year performance period. All awards, both new and renewal, will be based on rigorous peer review of the research proposed for the five year award term. Applicants requesting renewal funding will also be assessed on progress during the first five-year award.	The EFRCs that will be started in FY 2014 will perform the first year of research of the award period as outlined in their proposals. This multidisciplinary research will continue to provide accelerated progress in fundamental, energy-use inspired research. The research in these new EFRCs includes investigations of mesoscale science and utilization of computational research to predictably design new materials and processes. BES will hold a peer review to assess management and early operations.	FY 2015 support for EFRCs will continue at the FY 2014 level.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Energy Innovation Hubs—Fuels From Sunlight		
In FY 2014, JCAP performance milestones emphasize prototype development to test components for the integrated system. Areas of increased emphasis include analysis of components, materials and chemical inputs, and hardware designs with respect to manufacturability, life-cycle costs, and reusability to ensure the scalability of the first-generation, solar fuels generation system. Additional efforts are being made to fully optimize catalyst and systems efficiencies and to provide reviews of solar fuels research to the scientific community, establishing strong outreach efforts focused on workforce development necessary for development of a solar fuels industry.	The Fuels from Sunlight Hub completes its 5-year award at the planned level. Decision for continued funding beyond the 5 year term, which ends in September 2015, will be made in FY 2015.	The funding is approximately flat compared to FY 2014. A decision for continued funding beyond the initial five-year award term, which ends in September 2015, will be made in FY 2015.
General Plant Projects		
Funding is supporting minor facility improvements at Ames Laboratory.	Funding will support minor facility improvements at Ames Laboratory.	GPP support is flat compared to FY 2014.

Basic Energy Sciences
Scientific User Facilities

Description

The Scientific User Facilities subprogram supports the operation of a geographically diverse suite of major facilities that provide thousands of researchers from universities, industry, and government laboratories unique tools to advance a wide range of sciences. These user facilities are operated on an open access, competitive merit review basis, enabling scientists from every state and many disciplines from academia, national laboratories, and industry to utilize the facilities' unique capabilities and sophisticated instrumentation.

Studying matter at the level of atoms and molecules requires instruments that can probe structures that are one thousand times smaller than those detectable by the most advanced light microscopes. Thus, to characterize structures with atomic detail, we must use probes such as x-rays, electrons, and neutrons that are at least as small as the structures being investigated. The BES large-scale user facilities portfolio consists of a complementary set of intense x-ray sources, neutron scattering centers, and research centers for nanoscale science. These facilities allow researchers to probe materials in space, time, and energy with the appropriate resolutions that can interrogate the inner workings of matter to answer some of the most challenging grand science questions. By taking advantage of the intrinsic charge, mass, and magnetic characteristics of x-rays, neutrons, and electrons, these tools offer unique capabilities to help understand the fundamental aspects of the natural world.

Advances in tools and instruments often drive scientific discovery. The continual development and upgrade of the instrumental capabilities include new x-ray and neutron experimental stations, improved core facilities, and new stand-alone instruments. The subprogram also supports research in accelerator and detector development to explore technology options for the next generations of x-ray and neutron sources.

Annually, the BES scientific facilities are used by more than 15,000 scientists and engineers in many fields of science and technology. These facilities provide unique capabilities to the scientific community and are a critical component of maintaining U.S. leadership in the physical sciences. Collectively, these user facilities and enabling tools contribute to important research results that span the continuum from basic to applied research and embrace the full range of scientific and technological endeavors, including chemistry, physics, geology, materials science, environmental science, biology, and biomedical science. These capabilities enable scientific insights that can lead to the discovery and design of advanced materials and novel chemical processes with broad societal impacts, from energy applications to information technologies and biopharmaceutical discoveries. The advances enabled by these facilities extend from energy-efficient catalysts for clean energy production to spin-based electronics and new drugs for cancer therapy. For approved, peer-reviewed projects, operating time is available without charge to researchers who intend to publish their results in the open literature.

<u>Synchrotron Radiation Light Sources</u>

X-rays are an essential tool for studying the structure of matter and have long been used to peer into material through which visible light cannot penetrate. Today's synchrotron light source facilities produce x-rays that are billions of times brighter than medical x-rays. Scientists use these highly focused, intense beams of x-rays to reveal the identity and arrangement of atoms in a wide range of materials. The tiny wavelength of x-rays allows us to see things that visible light cannot resolve, such as the arrangement of atoms in metals, semiconductors, biological molecules, and other materials. The fundamental tenet of materials research is that structure determines function. The practical corollary that converts materials research from an intellectual exercise into a foundation of our modern technology-driven economy is that structure can be manipulated to construct materials with particular desired behaviors. To this end, synchrotron radiation has transformed the role of x-rays as a mainline tool for probing the atomic and electronic structure of materials internally and on their surfaces.

From its first systematic use as an experimental tool in the 1960s, synchrotron radiation has vastly enhanced the utility of pre-existing and contemporary techniques, such as x-ray diffraction, x-ray spectroscopy, and imaging and has given rise to scores of new ways to do experiments that would not otherwise be feasible with conventional x-ray machines. Moreover, the wavelength can be selected over a broad range (from the infrared to hard x-rays) to match the needs of particular experiments. Together with additional features, such as controllable polarization, coherence, and ultrafast pulsed time structure, these characteristics make synchrotron radiation the x-ray source of choice for a wide range of materials research. The wavelengths of the emitted photons span a range of dimensions from the atom to biological cells, thereby providing incisive probes for advanced research in a wide range of areas, including materials science, physical and chemical sciences, metrology, geosciences, environmental sciences, biosciences, medical sciences, and pharmaceutical sciences.

BES operates a suite of five light sources, including a free electron laser, the Linac Coherent Light Source (LCLS) at SLAC National Accelerator Laboratory (SLAC) and four storage ring based light sources—the Advanced Light Source (ALS) at Lawrence Berkeley National Laboratory (LBNL), Advanced Photon Source (APS) at Argonne National Laboratory (ANL), Stanford Synchrotron Radiation Lightsource (SSRL) at SLAC, and the National Synchrotron Light Source (NSLS) at Brookhaven National Laboratory (BNL), which will cease operation in FY 2015. NSLS-II will transition from early operations to full operations during FY 2015. Funds are provided to support facility operations, enable cutting-edge research and technical support, and to administer a robust user program at these facilities, which are made available to all researchers with access determined via peer review of user proposals.

High Flux Neutron Sources

One of the goals of modern materials science is to understand the factors that determine the properties of matter on the atomic scale and to use this knowledge to optimize those properties or to develop new materials and functionality. This process regularly involves the discovery of fascinating new physics, which itself may lead to previously unexpected applications. Among the different probes used to investigate atomic-scale structure and dynamics in scattering experiments, thermalized neutrons have unique advantages:

- they have a wavelength similar to the spacing between atoms, allowing atomic resolution studies of structure and have an energy similar to the elementary excitations of atoms and magnetic spins in materials, thus allowing an investigation of material dynamics;
- they have no charge, allowing deep penetration into a bulk material;
- they are scattered to a similar extent by both light and heavy atoms but differently by different isotopes of the same element, so that different chemical sites can be distinguished via isotope substitution experiments, for example in organic and biological materials;
- they have a magnetic moment, and thus can probe magnetism in condensed matter systems; and
- their scattering cross-section is precisely measurable on an absolute scale, facilitating straightforward comparison with theory and computer modeling.

The High Flux Isotope Reactor (HFIR) at Oak Ridge National Laboratory (ORNL) generates neutrons via fission in a research reactor. HFIR operates at 85 megawatts and provides state-of-the-art facilities for neutron scattering, materials irradiation, and neutron activation analysis. It is the world’s leading production source of elements heavier than plutonium for medical, industrial and research applications. There are 13 neutron scattering instruments installed in the reactor hall at HFIR and the adjacent new cold neutron beam guide hall and include world-class inelastic scattering spectrometers, small angle scattering, powder and single crystal diffractometers, neutron imaging, and an engineering diffraction machine.

Another approach for generating neutron beams is to use an accelerator to generate protons that strike a heavy-metal target. As a result of the impact, neutrons are produced in a process known as spallation. The Spallation Neutron Source (SNS) at ORNL is the world’s brightest pulsed neutron facility and presently includes 16 instruments. These instruments include very high resolution inelastic and quasi-elastic scattering capabilities, powder and single crystal diffraction, polarized and unpolarized beam reflectometry, spin echo and small angle scattering spectrometers. A full suite of high and low temperature, high magnetic field, and high pressure sample environment equipment is available on each instrument. These neutron instruments are in high demand by researchers world-wide in a range of disciplines from biology to materials sciences and condensed matter physics.

The Lujan Neutron Scattering Center at Los Alamos National Laboratory (LANL), a pulsed spallation source operating at about 100 kW, supports a target hall constructed by the Office of Science and instruments developed by SC and the National Nuclear Security Administration that address both of the needs of the basic research community and the NNSA mission of science-based stockpile stewardship. The seven BES-supported instruments focused primarily on powder diffraction, local structure determinations, liquids and polarized-beam reflectometry, and engineering diffraction. The neutron flux at the Lujan Center is an order of magnitude below what is available at the SNS. In FY 2015, BES operations at the Lujan Neutron Scattering Center will cease and funding is requested to transition the facility to a safe storage condition.

Nanoscale Science Research Centers (NSRCs)

Nanoscience is the study of materials and their behaviors at the nanometer scale—probing single atoms, clusters of atoms, and molecular structures. The scientific quest is to design, observe, and understand how nanoscale structures function, including how they interact with their environment. Developments at the nanoscale have the potential to make major contributions to delivering remarkable scientific discoveries that transform our understanding of energy and matter and advance national, economic, and energy security.

The NSRCs are DOE's premier user facilities for interdisciplinary research at the nanoscale, serving as the basis for a national program that encompasses new science, new tools, and new computing capabilities. The five NSRCs are the Center for Nanoscale Materials at ANL, Center for Functional Nanomaterials at BNL, Molecular Foundry at LBNL, Center for Nanophase Materials Sciences at ORNL, and Center for Integrated Nanotechnologies at SNL and LANL. Each center has particular expertise and capabilities, such as synthesis of nanomaterials; theory, modeling and simulation; imaging and spectroscopy including electron microscopy; and nanoscale integration. Selected thematic areas include catalysis, electronic materials, nanoscale photonics, and soft and biological materials. The centers are housed in custom-designed laboratory buildings near one or more other major BES facilities for x-ray, neutron, or electron scattering, which complement and leverage the capabilities of the NSRCs. These laboratories contain clean rooms, nanofabrication resources, one-of-a-kind signature instruments, and other instruments not generally available except at major user facilities. Operating funds are provided to enable cutting-edge research and technical support and to administer a robust user program at these facilities, which are made available to all researchers with access determined through external peer review of user proposals.

In FY 2015, the three electron-beam microcharacterization centers (EBMCs) will be merged administratively with their respective neighboring NSRCs. The three centers that will be merged are the Electron Microscopy Center for Materials Research at ANL, the National Center for Electron Microscopy at LBNL, and the Shared Research Equipment user facility at ORNL. The EBMCs provide superior spatial resolution and the ability to simultaneously obtain structural, chemical, and other types of information from sub-nanometer regions.

Other Project Costs

The total project cost (TPC) of DOE's construction projects comprises two major components—the total estimated cost (TEC) and other project costs (OPC). The TEC includes project costs incurred after Critical Decision-1, such as costs associated with all engineering design and inspection, the acquisition of land and land rights; direct and indirect construction/fabrication; and the initial equipment necessary to place the facility or installation in operation; and facility construction costs and other costs specifically related to those construction efforts. OPC represents all other costs related to the projects that are not included in the TEC. Generally, other project costs are incurred during the project's initiation and definition phase for planning, conceptual design, research, and development, and during the execution phase for research and development, startup, and commissioning. OPC is always funded via operating funds.

Major Items of Equipment

BES supports major item of equipment (MIE) projects to ensure the continual development and upgrade of major scientific instrument capabilities, including fabricating new x-ray and neutron experimental stations, improving core facilities, and providing new stand-alone instruments. In general, each MIE greater than $5,000,000 in total project cost and all line item construction projects follow the DOE Project Management Order 413.3B, which requires formal reviews to obtain critical decisions that advance the development stages of a project. Additional reviews may be required depending on the complexity and needs of the projects in question. BES MIE projects are in two main categories: Synchrotron Radiation Light Sources and High Flux Neutron Sources.

Research

This activity supports targeted basic research in accelerator physics, x-ray and neutron detectors, and developments of advanced x-ray optics. Accelerator research is the cornerstone for the development of new technologies that will improve performance of accelerator-based light sources and neutron scattering facilities. Research areas include ultrashort pulse free electron lasers (FELs), new seeding techniques and other optical manipulation to reduce the cost and complexity and improve performance of next generation FELs, and very high frequency laser photoinjectors that can influence the design of linac-based FELs with high repetition rates. Detector research is a crucial component to enable the optimal utilization of user facilities, together with the development of innovative optics instrumentation to advance photon-based sciences, and data management techniques. The emphasis of the detector activity is on research leading to new and more efficient photon and neutron detectors. Research includes studies on creating, manipulating, transporting, and performing diagnostics of ultrahigh brightness beams.

This activity also supports long term surveillance and maintenance (LTS&M) responsibilities and legacy cleanup work at Brookhaven National Laboratory and SLAC National Accelerator Laboratory. Prior to FY 2014, this activity was funded by the DOE Environmental Management (EM) program.

This activity historically supported the three electron-beam microcharacterization centers (EBMCs). Starting in FY 2015, each EBMC will be merged administratively with their respective neighboring NSRCs.

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Synchrotron Radiation Light Sources		
The FY 2014 appropriation continues the early operations of the NSLS-II in addition to supporting the operations of the five BES light source facilities at an average of about 97% of optimal levels.	In FY 2015, funding is requested for operations of the light sources at optimal levels, including early operations for the newly constructed NSLS-II. NSLS will cease operations and funds are provided to transition the facility to a safe storage condition in FY 2015.	Increases in funding allow for operations of ALS, APS, SSRL and LCLS at their optimal level. The National Synchrotron Light Source (NSLS) will cease operations. The NSLS-II will transition from a construction project to operations in FY 2015.
High-Flux Neutron Sources		
Funding is provided to continue the operation of HFIR and SNS at an average of about 97% of optimal levels. The Los Alamos Neutron Science Center (LANSCE) is undergoing an upgrade which reduces operations of the Lujan Center to 2,000 hours.	Funding is requested to continue the operation of HFIR and SNS at optimal levels. The BES operations at the Lujan Neutron Scattering Center will cease and funding is requested to transition the facility to a safe storage condition.	The increase in funding allows for optimal operations of HFIR and SNS. Decreased funding for the Lujan Center will transition the facility to a safe storage condition.
Nanoscale Science Research Centers		
Funding is provided to continue operations and support of users at the NSRCs at an average of about 97% of optimal levels. Continued emphasis will be to cultivate and expand the user base from universities, national laboratories, and industry.	Funding will continue operations and support of users at the NSRCs at the optimal level. The electron-beam microcharacterization centers (EBMCs) are merged with the NSRCs in FY 2015. Continued program emphasis will be to cultivate and expand the user base from universities, national laboratories, and industry. Efforts will include planning for future electron scattering needs that could address scientific roadblocks toward observing ultrafast chemical and physical phenomena at ultra-small size scales in different sample environments.	Increases in funding are due to the merger of the EBMCs with the NSRCs as well as improved operational levels.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Other Project Costs		
Funds are provided in FY 2014 for Other Project Costs associated with the NSLS-II project at BNL and the LCLS-II project at SLAC according to the project plan.	Funds are requested in FY 2015 for Other Project Costs associated with the LCLS-II project at SLAC according to the project plan.	NSLS-II OPC is decreased by $27,400,000 according to the project plan. LCLS-II OPC is decreased by $700,000.
Major Items of Equipment		
Plans for APS-U continue to evolve, taking the findings and recommendations of the July 25, 2013 BES Advisory Committee report into account. APS-U begins conceptual planning related to implementation of the multi-bend achromat lattice and starts limited prototyping activities.	APS-U will continue with planning and design, prototyping, and research and development related to implementation of the multi-bend achromat lattice during FY 2015.	APS-U funding is flat with FY 2014.
NEXT is anticipated to receive CD-3 approval in 3Q FY 2014. The project continues design and procurements (long lead and regular), and begins construction/fabrication activities during FY 2014.	NEXT will continue with the design, procurements, construction/fabrication, installation, testing and commissioning of equipment during FY 2015.	NEXT funding is decreased by $2,500.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Research		
Funding is provided to support optimal operations of the three electron beam microcharacterization centers. Research activities on FEL self-seeding and advanced accelerator methods continue. The accelerator physics and detector research is supported to maintain a balanced portfolio that continues to push the frontiers in accelerator and detector research. In anticipation of advances in source output flux and data volume, developments of advanced x-ray optics and data management techniques are necessary to fully realize advancements of accelerator and detector research. In FY 2014, responsibility is transferred from EM to BES for long term surveillance and maintenance (LTS&M) and for remaining legacy cleanup work scope at BNL and SLAC.	The research funding for the scientific user facilities is projected to maintain the FY 2014 level of effort in FY 2015, with modest increases to support selected, high-priority research activities. This funding increase will allow efforts in x-ray optics developments and data management techniques in addition to continue to support seminal advances in accelerator and detector research cognizant of the DOE mission needs and instrumentation relevant to neutron and photon based science. FY 2015 funding for the three Electron Beam Microcharacterization Centers (EBMCs) will be merged with the Nanoscale Science Research Centers (NSRCs) budget. Funding to continue the long term surveillance and maintenance responsibilities at BNL and SLAC is also included in this portion of the budget.	The funding for the three electron-beam micro characterization centers is moved to the Nanoscale Science Research Centers. Taking into account this change, research continues with a modest increase from the FY 2014 level, and includes additional efforts in x-ray optics developments and data management techniques.

Description

Reactors, accelerator-based x-ray light sources, and pulsed neutron sources are expensive but necessary user facilities that enable critical DOE mission-driven science. These user facilities provide the academic, laboratory, and industrial research communities with the tools to fabricate, characterize, and develop new materials and chemical processes to advance basic and applied research, advancing chemistry, physics, earth science, materials science, environmental science, biology, and biomedical science. Regular investments in construction of new user facilities and upgrades to existing user facilities are essential to maintaining U.S. leadership in these research areas.

The National Synchrotron Light Source-II (NSLS-II) construction project will complete construction and begin operations in FY 2015. NSLS-II will allow scientists to probe the fundamental properties of matter with nanometer-scale resolution and atomic sensitivity paving the way to new scientific discoveries and innovations. Taking the findings and recommendations of the July 25, 2013 BES Advisory Committee report into account, the Linac Coherent Light Source-II (LCLS-II) project will be modified to include the addition of a superconducting linear accelerator and additional undulators to generate an unprecedented high-repetition-rate free-electron laser. This new, world-leading, high-repetition-rate x-ray source will solidify the LCLS complex as the world leader in ultrafast x-ray science for decades to come.

All BES construction projects are conceived and planned with the scientific community and, during construction, adhere to the highest standards of safety and are executed on schedule and within cost through dogged project management. In accordance with DOE Order 413.3B, each project is closely monitored and must perform within 10% of the cost and schedule performance baselines, established at Critical Decision 2, Approve Performance Baseline, and which are reproduced in the construction project data sheet.

Activities and Explanation of Change

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Linac Coherent Light Source-II (LCLS-II)		
LCLS-II continues work to incorporate design changes, taking into account the findings and recommendations of the July 25, 2013 BES Advisory Committee report. Funding is provided for planning and project baseline development, engineering design, prototyping, and research and development activities.	The project will continue with design, initiate critical long-lead procurements of technical materials and cryogenics, continue research and development and prototyping activities, and fabrication of technical equipment during FY 2015.	LCLS-II funding is increased by $63,000,000. The funding will enable advancement of research and development activities, long-lead procurements, and prototyping.
National Synchrotron Light Source-II (NSLS-II)		
Funding requested for the civil construction will be ramped down, as scheduled.	No construction funding is requested for NSLS-II in FY 2015.	FY 2014 is the last year of construction funding for NSLS-II.

Basic Energy Sciences
Performance Measures

In accordance with the GPRA Modernization Act of 2010, the Department sets targets for, and tracks progress toward, achieving performance goals for each program. For more information, refer to the Department's FY 2013 Annual Performance Report.

	FY 2013	FY 2014	FY 2015
Performance Goal (Measure)	**BES Facility Operations—Average achieved operation time of BES user facilities as a percentage of total scheduled annual operation time**		
Target	≥ 90%	≥ 90%	≥ 90%
Result	Met	TBD	TBD
Endpoint Target	Many of the research projects that are undertaken at the Office of Science's scientific user facilities take a great deal of time, money, and effort to prepare and regularly have a very short window of opportunity to run. If the facility is not operating as expected the experiment could be ruined or critically setback. In addition, taxpayers have invested millions or even hundreds of millions of dollars in these facilities. The greater the period of reliable operations, the greater the return on the taxpayers' investment.		
Performance Goal (Measure)	**BES Facility Construction/MIE Cost & Schedule—Cost-weighted mean percent variance from established cost and schedule baselines for major construction, upgrade, or equipment procurement projects.**		
Target	< 10%	< 10%	< 10%
Result	Met	TBD	TBD
Endpoint Target	Adhering to the cost and schedule baselines for a complex, large scale, science project is critical to meeting the scientific requirements for the project and for being good stewards of the taxpayers' investment in the project.		

	FY 2013	FY 2014	FY 2015
Performance Goal (Measure)	**BES Solar Fuels—Demonstrate a scalable solar-fuels generator using Earth-abundant elements that produces fuel (without wires) from the sun 10 times more efficiently than current agriculturally produced plants**		
Target	Establish benchmarking capabilities for comparison of homogeneous/heterogeneous catalysts and light absorbers under standardized testing conditions	Design first prototype device for testing components, such as catalysts, light harvesters, membranes, and interfaces, as an integrated system	N/A
Result	Met	TBD	TBD
Endpoint Target	Demonstration of a scalable solar-fuels generator using Earth-abundant elements that produces fuel (without wires) from the sun 10 times more efficiently than current agriculturally produced plants. The performance goal will be achieved by the *Fuels from Sunlight* Energy Innovation Hub.		
Performance Goal (Measure)	**BES Energy Storage—Deliver two high-performance research energy storage prototypes for transportation and the grid that project at the battery pack level to be five times the energy density at 1/5 the cost of the 2011 commercial baseline.**		
Target	N/A	N/A	Through the "electrolyte genome," demonstrate a framework for designing new electrolytes using structure-chemical trends extracted from >10,000 first-principles calculated molecular motifs, modifications and mutations
Result	N/A	N/A	TBD
Endpoint Target	Deliver two high-performance research prototypes for transportation and the grid that project at the battery pack level to be five times the energy density at 1/5 the cost of the 2011 commercial baseline. The performance goal will be achieved by the *Batteries and Energy Storage* Energy Innovation Hub.		

Basic Energy Science
Capital Summary ($K)

	Total	Prior Years	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Capital Operating Expenses Summary							
Capital Equipment	n/a	n/a	75,931	50,100	50,100	44,500	-5,600
General Plant Projects (GPP)	n/a	n/a	7,000	600	600	600	0
Accelerator Improvement Projects (AIP)	n/a	n/a	9,050	9,000	9,000	13,475	+4,475
Total, Capital Operating Expenses	n/a	n/a	91,981	59,700	59,700	58,575	-1,125
Capital Equipment							
Major Items of Equipment							
Advanced Photon Source Upgrade (APS-U), ANL (TPC TBD)	TBD[a]	20,000	20,000	20,000	20,000	20,000	0
Linac Coherent Light Source-II (LCLS-II), SLAC	—[b]	44,500[c]	22,500[d]	0[b]	0[b]	0[b]	0
NSLS-II Experimental Tools (NEXT), BNL (TPC $90,000)	90,000	15,000	12,000	25,000	25,000	22,500	-2,500
Total, Major Items of Equipment	**n/a**	**n/a**	**54,500**	**45,000**	**45,000**	**42,500**	**-2,500**
Other capital equipment projects under $2 million TEC	n/a	n/a	21,431	5,100	5,100	2,000	-3,100
Total, Capital equipment	**n/a**	**n/a**	**75,931**	**50,100**	**50,100**	**44,500**	**-5,600**
General Plant Projects (GPP)							
Ames Sensitive Instrument Facility	9,900	5,500	4,400	0	0	0	0
Combustion Research Facility	9,200	8,250[e]	950	0	0	0	0
Other general plant projects under $5 million TEC	n/a	n/a	1,650	600	600	600	0
Total, General Plant Projects	n/a	n/a	7,000	600	600	600	0
Accelerator Improvement Projects (AIP)							
Accelerator improvement projects under $5 million TEC	n/a	n/a	9,050	9,000	9,000	13,475	+4,475

[a] Following the July 2013 BESAC report on Future X-Ray Light Sources, the APS-U project has been rescoped and a revised CD-0 document is in preparation.
[b] LCLS-II is requested as a line item construction project in FY 2014 and FY 2015.
[c] LCLS-II received $30,000,000 in FY 2012 as a MIE ($22,000,000 as TEC and $8,000,000 as OPC). FY 2012 funds in the amount of $22,500,000 were also provided to LCLS-II in FY 2013. Prior to FY 2014, LCLS-II was an MIE.
[d] FY 2013 funding was requested as a line item, but due to the Continuing Resolution, FY 2013 funds are executed as a MIE.
[e] $2,550,000 was provided by the Energy Efficiency and Renewable Energy program and Sandia National Laboratories.

Major Items of Equipment Descriptions

Advanced Photon Source Upgrade (APS-U)

The Advanced Photon Source Upgrade (APS-U) MIE supports activities to design, build, install, and test the equipment necessary to upgrade an existing third-generation synchrotron light source facility, the Advanced Photon Source (APS). The APS is one of the Nation's most productive x-ray light source facilities, serving over 4,000 users annually and providing key capabilities to enable forefront scientific research in a broad range of fields of physical and biological sciences. The APS is the only hard x-ray 7 GeV source in the U.S. and only one of four in the world, along with the European Synchrotron Radiation Facility (ESRF) in France, PETRA-III in Germany, and Spring-8 in Japan. High-energy penetrating x-rays are especially critical for probing materials under real working environments, such as a battery or fuel cell in action. All three foreign facilities are well into campaigns of major upgrades of beamlines and also incorporating technological advancements in accelerator science. With the ever increasing demand for higher penetration power for probing real-world materials and applications, the higher energy hard x-rays (20 keV and above) produced at APS provide unique capabilities in the U.S. arsenal needed for tackling the grand science and energy challenges of the 21st Century. In response to the findings and recommendations of the July 25, 2013 BES Advisory Committee report, the APS-U Project will upgrade the existing APS to provide scientists with an x-ray source possessing world-leading transverse coherence and extreme brightness. The magnetic lattice of the APS storage ring will be upgraded to a multi-bend achromat configuration to provide brightness enhancements. The APS upgrade will ensure that the APS remains a world leader in hard x-ray science. The high-energy penetrating x-rays will provide a unique scientific capability directly relevant to problems in energy, the environment, new and improved materials, and biological studies. The upgraded APS will complement the capabilities of the 4th generation light sources (e.g., the Linac Coherent Light Source and Linac Coherent Light Source-II), which occupy different spectral, flux, and temporal range of technical specifications. The project is managed by Argonne National Laboratory.

NSLS-II Experimental Tools (NEXT)

The NSLS-II Experimental Tools (NEXT) MIE supports activities to add beamlines to the National Synchrotron Light Source-II (NSLS-II) Project. The NEXT Project will provide NSLS-II with complementary best-in-class beamlines that support the identified needs of the U.S. research community and the DOE energy mission. Implementation of this state-of-the-art instrumentation will significantly increase the scientific quality and productivity of NSLS-II. In addition, the NEXT project will enable and enhance more efficient operation of NSLS-II. The project is managed by Brookhaven National Laboratory.

Construction Projects Summary ($K)

	Total	Prior Years	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
13-SC-10, Linac Coherent Light Source-II (LCLS-II), SLAC							
TEC	846,400	0[a]	0[b]	75,700	75,700	138,700	+63,000
OPC	48,600	10,600	0	10,000	10,000	9,300	-700
TPC	**895,000**	**10,600**	**0**	**85,700**	**85,700**	**148,000**	**+62,300**
07-SC-06, National Synchrotron Light Source-II, BNL							
TEC	791,200	717,697	47,203	26,300	26,300	0	-26,300
OPC	120,800	69,000	24,400	27,400	27,400	0	-27,400
TPC	**912,000**	**786,697**	**71,603**	**53,700**	**53,700**	**0**	**-53,700**
Total, Construction							
TEC	n/a	n/a	47,203[b]	102,000	102,000	138,700	+36,700
OPC	n/a	n/a	24,400	37,400	37,400	9,300	-28,100
TPC	**n/a**	**n/a**	**71,603**	**139,400**	**139,400**	**148,000**	**+8,600**

Funding Summary ($K)

	FY 2013 Current	FY 2014 Enacted	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Research	676,085	698,962	711,250	+12,288
Scientific User Facilities Operations	743,118	778,785	851,454	+72,669
Major Items of Equipment	54,500	45,000	42,500	-2,500
Construction Projects (includes OPC)	71,603	139,400	148,000	+8,600
Other[c]	5,950	49,782	53,296	+3,514
Total, Basic Energy Sciences	**1,551,256**	**1,711,929**	**1,806,500**	**+94,571**

[a] LCLS-II received $30,000,000 in FY 2012 as an MIE ($22,000,000 as TEC and $8,000,000 as OPC). FY 2012 funds in the amount of $22,500,000 were also provided to LCLS-II in FY 2013.

[b] FY 2013 funding was requested as a line item, but due to a Continuing Resolution, $22,500,000 in FY 2013 was executed as an MIE.

[c] Includes SBIR/STTR funding and non-Facility related GPP.

Facility Operations ($K)

	FY 2013 Current	FY 2014 Enacted	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Advanced Light Source	$59,500	$60,000	$63,307	+$3,307
Achieved operating hours	4,891	N/A	N/A	
Planned operating hours	4,700	5,100	5,600	+500
Optimal hours	4,800[a]	5,300[b]	5,600	+300
Percent of optimal hours	101.9%	96.2%	100.0%	
Unscheduled downtime percentage	<10%	<10%	<10%	
Number of users	2,222	1,800	2,000	+200
Advanced Photon Source	$120,170	$123,000	$129,852	+$6,852
Achieved operating hours	4,895	N/A	N/A	
Planned operating hours	5,000	5,000	5,000	0
Optimal hours	5,000	5,000	5,000	0
Percent of optimal hours	97.9%	100%	100%	
Unscheduled downtime percentage	<10%	<10%	<10%	
Number of users	4,542	4,500	4,600	+100
National Synchrotron Light Source, BNL	$33,000	$30,000	$5,500	-$24,500
Achieved operating hours	5,538	N/A	N/A	
Planned operating hours	4,500	4,400	0	-4,400
Optimal hours	4,500[a]	4,500[b]	0	-4,500
Percent of optimal hours	123.1%	97.8%	0	
Unscheduled downtime percentage	<10%	<10%	0	
Number of users	2,367	1,500	0	-1,500
National Synchrotron Light Source-II, BNL	$22,000	$56,000	$115,000	+$59,000
Achieved operating hours	N/A	N/A	N/A	N/A
Planned operating hours	0	0	2,500	+2,500
Optimal hours	0	0	2,500	+2,500
Percent of optimal hours	0	0	100%	0

[a] The optimal hours for ALS are adjusted from 5,600 to 4,800 hours in FY 2013 and 5,600 to 5,300 hours in FY 2014 to allow for installation of new hardware and maintenance activities.

[b] The optimal hours for NSLS are adjusted from 5,400 to 4,500 hours in FY 2013 and FY 2014 as part of the transition plan for ramping down NSLS operations.

	FY 2013 Current	FY 2014 Enacted	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Unscheduled downtime percentage	0	0	<10%	0
Number of users	0	0	250	+250
Stanford Synchrotron Radiation Lightsource	$38,500	$38,500	$38,860	+$360
Achieved operating hours	5,160	N/A	N/A	
Planned operating hours	5,000	5,400	5,400	0
Optimal hours	5,200	5,400	5,400	0
Percent of optimal hours	99.2%	100%	100%	
Unscheduled downtime percentage	<10%	<10%	<10%	
Number of users	1,675	1,500	1,500	0
Linac Coherent Light Source	$123,000	$124,500	$131,647	+$7,147
Achieved operating hours	4,580	N/A	N/A	
Planned operating hours	4,100	4,400	4,500	+100
Optimal hours	4,500	4,500	4,500	0
Percent of optimal hours	101.8%	97.8%	100%	
Unscheduled downtime percentage	<10%	<10%	<10%	
Number of users	594	500	550	+50
High Flux Isotope Reactor	$58,000	$58,000	$60,030	+$2,030
Achieved operating hours	3,629	N/A	N/A	
Planned operating hours	3,300	3,400	3,500	+100
Optimal hours	3,400	3,500	3,500	0
Percent of optimal hours	106.7%	97.1%	100%	
Unscheduled downtime percentage	<10%	<10%	<10%	
Number of users	395	400	450	+50
Lujan Neutron Scattering Center	$10,000	$8,900	$2,000	-$6,900
Achieved operating hours	1,597	N/A	N/A	
Planned operating hours	3,000	1,300	0	-1,300
Optimal hours	3,000	2,000[a]	0	-2,000
Percent of optimal hours	53.2%	65.0%		
Unscheduled downtime percentage	<10%	<10%		

[a] The optimal hours for Lujan are adjusted from 3,000 to 2,000 hours in FY 2014 reflecting limited availability of LANSCE.

	FY 2013 Current	FY 2014 Enacted	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Number of users	208	150	0	-150
Spallation Neutron Source	$178,448	$179,000	$186,460	+$7,460
Achieved operating hours	4,270	N/A	N/A	
Planned operating hours	4,200	4,400	4,500	+100
Optimal hours	4,500	4,500	4,500	0
Percent of optimal hours	94.9%	97.8%	100%	
Unscheduled downtime percentage	<10%	<10%	<10%	
Number of users	726	750	800	+50
Center for Nanoscale Materials[a]	$20,050	$20,100	$24,405	+$4,305
Number of users	454	400	500	+100
Center for Functional Nanomaterials[a]	$19,550	$19,600	$20,700	+$1,100
Number of users	439	400	400	0
Molecular Foundry[a]	$20,050	$20,150	$27,614	+$7,464
Number of users	451	400	500	+100
Center for Nanophase Materials Sciences[a]	$20,300	$20,350	$24,344	+$3,994
Number of users	467	400	500	+100
Center for Integrated Nanotechnologies[a]	$20,550	$20,685	$21,735	+$1,050
Number of users	447	400	400	0
Total, All Facilities	$743,118	$778,785	$851,454	+$72,669
Achieved operating hours	34,560	N/A	N/A	
Planned operating hours	33,800	33,400	31,000	-2,400
Optimal hours	34,900	34,700	31,000	-3,700
Percent of optimal hours (funding weighted)	99.7%	97.7%	100.0%	
Unscheduled downtime percentage	0%	<10%	<10%	
Number of users	14,987	13,100	12,450	-650

[a] Facility operating hours are not measured at user facilities that do not rely on one central machine.

Scientific Employment

	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	FY 2015 vs. FY 2014
Number of permanent Ph.D.'s (FTEs)	4,680	4,450	4,490	+40
Number of postdoctoral associates (FTEs)	1,310	1,170	1,160	-10
Number of graduate students (FTEs)	2,050	1,740	1,730	-10

13-SC-10, Linac Coherent Light Source-II
SLAC National Accelerator Laboratory, Menlo Park, California
Project is for Design and Construction

1. Summary and Significant Changes

The Linac Coherent Light Source-II (LCLS-II) was initially designated as a major item of equipment (MIE). The FY 2013 request proposed funding LCLS-II as a construction project, but FY 2014 is the first year that construction project funding was appropriated. The FY 2015 LCLS-II project data sheet (PDS) shows both MIE and construction funding in order to convey the full scope of the project's funding. The LCLS-II project described in this PDS is a significant revision to the project described in previous years.

In January 2013, the Director of the Office of Science (SC) charged the BESAC to assess the Grand Science Challenges that could best be explored with current and possible future SC light sources and to provide light source specifications that would maximize their impact. A 22-member BESAC subcommittee used prior BESAC reports and new input from the x-ray sciences communities to formulate findings and recommendations. In July 2013, BESAC accepted the "Report of the BESAC Subcommittee on Future X-ray Light Sources" and delivered to the Office of Science their findings and recommendations, which are formulated to ensure that the U.S. maintains its preeminence in the critically important field of x-ray science by providing the U.S. x-ray user community with world leading performance from its free electron laser (FEL) and storage ring based x-ray sources.

Based on this report, the Office of Science directed the SLAC National Accelerator Laboratory (SLAC) to assess whether and how the BESAC recommendations could be incorporated into the LCLS-II project. The discussions that ensued resulted in the updated LCLS-II project presented here, which will build upon the exceptional characteristics of the LCLS for the production of hard x-rays and incorporate superconducting linear accelerator technology to enable high repetition rate operation up to 5 keV photon energies. The revised LCLS-II project will have the broadest photon energy range and the highest energy per pulse, and it will be the only high repetition rate FEL in the world. It will provide unprecedented x-ray properties for the combined control of spatial, temporal, and energy resolution that will enable groundbreaking research in a wide range of scientific disciplines.

The revised preliminary Total Project Cost (TPC) range supporting the recent BESAC recommendations and proposed technical approach is $750,000,000–$1,200,000,000. Prior to the BESAC recommendations, the most recent DOE 413.3B approved Critical Decision, CD-3A (Approve Long Lead Procurement (LLP) Baseline and Start of LLP), was approved on March 14, 2012. The preliminary TPC range for the project at that time was $350,000,000–$500,000,000. The addition of the superconducting linac and the cryogenic systems to enable the high repetition rate account for the cost increase.

The Mission Need Statement has been updated. The Acquisition Strategy is being revised to support the new technical approach. The cost estimate and range are being refined based upon the new technical strategy. The project will seek new long lead procurement authorization supporting the revised technical strategy as detailed requirements are refined.

A Federal Project Director has been assigned to this project and is certified to Level 4.

This PDS is not a new start for the FY 2015 budget year.

This PDS is an update of the FY 2014 proposal.

2. Critical Decision (CD) and D&D Schedule

(fiscal quarter or date)

	CD-0	CD-1	Design Complete	CD-2	CD-3A	CD-3B	CD-4	D&D
FY 2013	4/22/2010	10/14/2011	4Q FY 2016	1Q FY 2013	3/14/2012	3Q FY 2013	4Q FY 2019	N/A
FY 2014	4/22/2010	10/14/2011	4Q FY 2016	4Q FY 2013	3/14/2012	4Q FY 2013	4Q FY 2019	N/A
FY 2015	4/22/2010	10/14/2011	4Q FY 2017[a]	4Q FY 2015[a]	3/14/2012[a]	4Q FY 2016[a]	4Q FY 2021[a]	N/A

CD-0 – Approve Mission Need
CD-1 – Approve Alternative Selection and Cost Range
CD-2 – Approve Performance Baseline
CD-3A – Approve Long-Lead Procurements
CD-3 – Approve Start of Construction
CD-4 – Approve Start of Operations or Project Closeout

3. Baseline and Validation Status

(dollars in thousands)

	TEC, Design	TEC, Construction	TEC, Total	OPC, Except D&D	OPC, D&D	OPC, Total	TPC
FY 2013	18,000	367,000	385,000	20,000	0	20,000	405,000
FY 2014[a]	18,000	367,000	385,000	20,000	0	20,000	405,000
FY 2015[a]	47,000[b]	799,400[b]	846,400	48,600	0	48,600[b]	895,000[b]

4. Project Description, Scope and Justification

Mission Need

The LCLS-II project's purpose is to expand the x-ray spectral operating range and the user capacity of the existing Linac Coherent Light Source (LCLS) facility. The expanded spectral range will enable researchers to tackle new research frontiers. The capacity increase is critically needed as the demand for LCLS capabilities far exceeds the available time allocation to users. The revised LCLS-II presented in this PDS is informed by 2013 BESAC recommendations to provide "high repetition rate, ultra-bright, transform limited, femtosecond x-ray pulses over a broad photon energy (about 0.2–5 keV) with full spatial and temporal coherence" and the "linac should feed multiple independently tunable undulators each of which could have multiple endstations." Collectively, the project will enable groundbreaking research in a wide range of scientific disciplines in chemical, material and biological sciences.

Scope and Justification for 13-SC-10 Linac Coherent Light Source II

SLAC's advances in the creation, compression, transport, and monitoring of bright electron beams have spawned a new generation of x-ray radiation sources based on linear accelerators rather than on storage rings. The LCLS produces a high-brightness x-ray beam with properties vastly exceeding those of current x-ray sources in three key areas: peak brightness, coherence, and ultrashort pulses. The peak brightness of the LCLS is 10 billion times greater than current synchrotrons,

[a] This project is pre-CD-2; the estimated schedule is preliminary. Construction will not be executed without appropriate CD approvals.
[b] Includes MIE funding of $7,000,000 for the design phase and $60,000,000 for the construction phases, which results in $67,000,000 of TEC funding, as well as $18,600,000 of OPC funding, for a total of $85,600,000 of MIE funding in the TPC.

providing up to 10^{12} x-ray photons in a pulse with duration in the range of 3–500 femtoseconds. These characteristics of the LCLS have opened new realms of research in the chemical, material, and biological sciences. LCLS-II will build on the success of LCLS by expanding the spectral range of hard x-rays produced at the facility and adding a new high repetition rate, spectrally tunable x-ray source. The repetition rate for x-ray production in the 0.2–5 keV range will be increased by at least a factor of 1,000 to yield unprecedented high average brightness x-rays that will be unique worldwide.

LCLS is based on the existing SLAC linear accelerator (linac), which is not a superconducting linac. The linac was originally designed to accelerate electrons and positrons to 50 GeV for colliding beam experiments and for nuclear and high energy physics experiments on fixed targets and was later adapted for use as a FEL (the LCLS facility) and for advanced accelerator research. At present, the last third of the 3 kilometer linac is being used to operate the LCLS facility, and the first 2 kilometers are used for advanced accelerator research.

The initial LCLS-II project, described in the FY 2014 PDS, was to use the second kilometer of the linac to produce high-brightness (13.5 GeV) electron bunches at a 120 Hz repetition rate. These electron bunches would have been sent to a new undulator tunnel to produce two x-ray beams spanning a tunable photon energy range beyond the existing LCLS facility. Use of the first and third kilometers of the linac would have remained unchanged.

The revised LCLS-II project will construct a new high repetition rate electron injector and replace the first kilometer of the linac with a 4 GeV superconducting linac to create the electron beam required for x-ray production in the 0.2–5 keV range with a repetition rate near 1 MHz. The new electron beam will be transported to the existing undulator hall and will be capable of feeding either of the two new variable gap undulators.

The third kilometer of the linac will continue to produce 14 GeV electron bunches for hard x-ray production at a 120 Hz repetition rate. The electron bunches will be sent to both of the new undulators to produce two simultaneous x-ray beams. The x-ray beams will span a tunable photon energy range of 5 to 25 keV, beyond the range of the existing LCLS facility, and they will incorporate "self seeding sections" to greatly enhance the longitudinal coherence of the x-ray beams. The middle kilometer of the existing linac will not be used as part of LCLS-II but will continue to be used for advanced accelerator research and it would be available for future expansion of the LCLS-II capabilities.

At the completion of the LCLS-II project, the facility will operate two independent electron linacs and two independent x-ray sources, supporting up to six experiment stations. Both the capability and capacity of the facility will be significantly enhanced. The combined characteristics (spectral content, peak power, average brightness, pulse duration, and coherence) of the new x-ray sources will surpass the present capabilities of the LCLS beam in spectral tuning range and brightness. The high repetition rate will accommodate more experiments. Furthermore, the two new undulators will be independently controlled to enable more experiments to be conducted simultaneously.

Experience with LCLS has, for the first time, provided data on performance of the x-ray instrumentation and optics required for scientific experiments with the LCLS. The LCLS-II project will take advantage of this knowledge base to design LCLS-II x-ray transport, optics, and diagnostics matched to the characteristics of these sources. The LCLS-II project scope is able to leverage the existing suite of LCLS instrumentation for characterization of the x-ray sources with moderate upgrades primarily to address the higher repetition rate operation.

The existing LCLS Beam Transport and Undulator Hall will be modified as necessary to house the new undulators, electron beam dumps, and x-ray optics. The existing experimental stations will be updated as necessary for the exploitation of the new x-ray sources. In contrast to the initial version of the project, construction of a new undulator tunnel and a new instrument suite will not be required.

The LCLS-II project will develop strategic partnerships with other SC laboratories for the design, fabrication, installation, and commissioning of the new superconducting linear accelerator, the high repetition rate electron injector and the new variable gap undulators.

Funding for conceptual design in FY 2011 supported the creation of the initial facility concept. The project initiated engineering design and long lead procurements in FY 2012 as an MIE. FY 2013 funding continued long lead procurements, design of technical equipment, R&D, and prototyping of key technical components. FY 2014 funding continues design work, critical long-lead procurements of technical materials and cryogenics, R&D, prototyping activities, and fabrication of technical equipment. The Mission Need Statement has been updated. An updated Acquisition Strategy is being developed. FY 2015 activities will include design, long lead procurements, R&D, prototyping, construction/fabrication, and installation activities.

Key Performance Parameters (KPPs)

The Threshold KPPs, which will define the official performance baseline at CD-2, represent the minimum acceptable performance that the project must achieve. Achievement of the Threshold KPPs will be a prerequisite for approval of CD-4, Project Completion. The Objective KPPs represent the desired project performance. If project performance is sustained and funds are available, the project will strive to attain the Objective KPPs. The KPPs presented here are preliminary, pre-baseline values. The final key parameters will be established as part of CD-2, Performance Baseline.

Preliminary LCLS-II Key Performance Parameters

Performance Measure	Threshold	Objective
Variable gap undulators	2 (soft and hard x-ray)	2 (soft and hard x-ray)
Superconducting linac-based FEL system		
Superconducting linac electron beam energy	3 GeV	≥ 4 GeV
Superconducting linac repetition rate	50 kHz	1,000 kHz
Superconducting linac charge per bunch	0.02 nC	0.1 nC
Photon beam energy range	250–2,800 eV	200–5,000 eV
High repetition rate capable end stations	≥ 1	≥ 2
FEL photon quantity (10^{-3} BW[a])	10^{9} (10x spontaneous @ 2.5 keV)	> 10^{11} @ 2.5 keV
Normal conducting linac-based system		
Normal conducting linac electron beam energy	13 GeV	15 GeV
Normal conducting linac repetition rate	120 Hz	120 Hz
Normal conducting linac charge per bunch	0.1 nC	0.25 nC
Photon beam energy range	1–13,000 eV	1–25,000 eV
Low repetition rate capable end stations	≥ 2	≥ 3
FEL photon quantity (10^{-3} BW)	10^{10} (10x spontaneous @ 13 keV)	> 10^{12} @ 13 keV

[a] Fractional bandwidth. The specified KPPs are the number of photons with an energy within 0.1% of the specified central value.

5. Financial Schedule

(dollars in thousands)

	Appropriations	Obligations	Costs
Total Estimated Cost (TEC)			
Design phase			
MIE funding			
FY 2012	2,000[a]	2,000	2,000
FY 2013	5,000[b]	5,000	5,000
Total, MIE funding	7,000	7,000	7,000
Line item construction funding			
FY 2014	4,000	4,000	4,000
FY 2015	21,000	21,000	20,000
FY 2016	15,000	15,000	14,000
FY 2017	0	0	2,000
Total, Line item construction funding	40,000[c]	40,000	40,000
Total, Design phase	47,000	47,000	47,000
Construction phase			
MIE funding			
FY 2012	42,500[d]	20,000[a]	13,862
FY 2013	17,500[e]	40,000[a]	27,285
FY 2014	0	0	18,853
Total, MIE funding	60,000	60,000	60,000
Line item construction funding			
FY 2014	71,700	71,700	47,147
FY 2015	117,700	117,700	108,000
FY 2016	189,000	189,000	180,000
FY 2017	185,100	185,100	185,100
FY 2018	156,000	156,000	168,000
FY 2019	19,900	19,900	27,700

[a] FY 2012 funding was executed as an MIE. FY 2012 funding was used for design and long lead procurement.
[b] FY 2013 funding was requested as a line item, but due to a Continuing Resolution, FY 2013 funds were executed as an MIE.
[c] This project has not yet received CD-2 approval; funding estimates are preliminary.
[d] FY 2012 funding shown includes $22,500,000 of prior year balances from FY 2012 that was reallocated to the LCLS-II project during FY 2013.
[e] FY 2013 funding was requested as a line item, but due to a continuing resolution, FY 2013 funds were executed as a MIE.

(dollars in thousands)

	Appropriations	Obligations	Costs
FY 2020	0	0	23,453
Total, Line item construction funding	739,400	739,400	739,400
Total, Construction phase	799,400	799,400	799,400
TEC			
MIE funding			
FY 2012	44,500[a]	22,000[a]	15,862
FY 2013	22,500[b]	45,000[a]	32,285
FY 2014	0	0	18,853
Total, MIE funding	67,000	67,000	67,000
Line item construction funding			
FY 2014	75,700	75,700	51,147
FY 2015	138,700	138,700	128,000
FY 2016	204,000	204,000	194,000
FY 2017	185,100	185,100	187,100
FY 2018	156,000	156,000	168,000
FY 2019	19,900	19,900	27,700
FY 2020	0	0	23,453
Total, Line item construction funding	779,400	779,400	779,400
Total, TEC	846,400[c]	846,400[c]	846,400[c]
Other Project Cost (OPC)			
OPC except D&D			
MIE funding			
FY 2010	1,126	1,126	938
FY 2011	9,474	9,474	8,033
FY 2012	8,000[a]	8,000	8,893
FY 2013	0	0	116
FY 2014	0	0	620
Total, MIE funding	18,600	18,600	18,600

[a] FY 2012 funding was executed as an MIE. FY 2012 funding was used for design and long lead procurement.
[b] FY 2013 funding was requested as a line item, but due to a Continuing Resolution, FY 2013 funds were executed as an MIE.
[c] This project has not yet received CD-2 approval; funding estimates are preliminary. Amounts shown include MIE funding of $67,000,000 in the TEC, $18,600,000 in the OPC, and $85,600,000 in the TPC.

(dollars in thousands)

	Appropriations	Obligations	Costs
Line item construction funding			
FY 2014	10,000	10,000	80
FY 2015	9,300	9,300	9,300
FY 2016	0	0	5,000
FY 2017	0	0	0
FY 2018	5,900	5,900	8,000
FY 2019	4,800	4,800	7,000
FY 2020	0	0	620
Total, Line item construction funding	30,000	30,000	30,000
Total, OPC	48,600[a]	48,600[a]	48,600[a]
Total Project Cost (TPC)			
MIE funding			
FY 2010	1,126	1,126	938
FY 2011	9,474	9,474	8,033
FY 2012	52,500[b]	30,000	24,755
FY 2013	22,500[c]	45,000	32,401
FY 2014	0	0	19,473
Total, MIE funding	85,600	85,600	85,600
Line item construction funding			
FY 2014	85,700	85,700	51,227
FY 2015	148,000	148,000	137,300
FY 2016	204,000	204,000	199,000
FY 2017	185,100	185,100	187,100
FY 2018	161,900	161,900	176,000
FY 2019	24,700	24,700	34,700
FY 2020	0	0	24,073
Total, Line item construction funding	809,400	809,400	809,400
Total, TPC	895,000[a]	895,000[a]	895,000[a]

[a] This project has not yet received CD-2 approval; funding estimates are preliminary. Amounts shown include MIE funding of $67,000,000 in the TEC, $18,600,000 in the OPC, and $85,600,000 in the TPC.

[b] FY 2012 funding shown includes $22,500,000 of prior year balances from FY 2012 that was reallocated to the LCLS-II project during FY 2013.

[c] FY 2013 funding was requested as a line item, but due to a continuing resolution, FY 2013 funds were executed as an MIE.

6. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design			
Design	37,770	16,500	N/A
Contingency	9,230	1,500	N/A
Total, Design	47,000	18,000	N/A
Construction			
Site Preparation	4,700	4,700	N/A
Equipment	564,800	189,370	N/A
Other Construction	38,500	95,243	N/A
Contingency	191,400	77,687	N/A
Total, Construction	799,400[a]	367,000[a]	N/A
Total, TEC	846,400[a]	385,000[a]	N/A
Contingency, TEC	200,630	79,187	N/A
Other Project Cost (OPC)			
OPC except D&D			
Conceptual Planning	1,980	1,126	N/A
Conceptual Design	23,658	14,974	N/A
Research and Development	1,972	1,100	N/A
Start-Up	11,550	1,920	N/A
Contingency	9,440	880	N/A
Total, OPC	48,600[a]	20,000[a]	N/A
Contingency, OPC	9,440	880	N/A
Total, TPC	895,000[a]	405,000[a]	N/A
Total, Contingency	210,070	80,067	N/A

[a] This project has not yet received CD-2 approval; funding estimates are preliminary. Amounts shown include MIE funding of $67,000,000 in the TEC, $18,600,000 in the OPC, and $85,600,000 in the TPC, as detailed in table 5.

7. Schedule of Appropriations Requests

(dollars in thousands)

Request Year		Prior Years	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	Total
FY 2012 (MIE)	TEC	0	22,000	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
	OPC	10,600	8,000	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
	TPC	10,600	30,000	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
FY 2013 (MIE)[a]	TEC	0	22,000	63,500	80,300	94,000	105,300	19,900	0	0	385,000
	OPC	10,600	8,000	0	700	0	700	0	0	0	20,000
	TPC	10,600	30,000	63,500	81,000	94,000	106,000	19,900	0	0	405,000
FY 2014	TEC	0	22,000	—[b]	95,000	122,500	100,500	0	0	0	385,000
	OPC	10,600	8,000	—[b]	700	0	700	0	0	0	20,000
	TPC	10,600	30,000	—[b]	95,700	122,500	101,200	0	0	0	405,000
FY 2015	TEC	0	22,000	45,000	75,700	138,700	204,000	185,100	156,000	19,900	846,400[c]
	OPC	10,600	8,000	0	10,000	9,300	0	0	5,900	4,800	48,600[c]
	TPC	10,600	30,000	45,000	85,700	148,000	204,000	185,100	161,900	24,700	895,000[c]

8. Related Operations and Maintenance Funding Requirements

Not applicable. Project does not have CD-2 approval.

9. Required D&D Information

Area of existing facility being replaced and D&D'ed by this project:	N/A
Area of additional D&D space to meet the "one-for-one" requirement from the banked area:	All new construction has been offset by existing SLAC and DOE banked space.

10. Acquisition Approach

DOE has determined that the LCLS-II project will be acquired by the SLAC National Accelerator Laboratory under the existing DOE M&O contract.

A Conceptual Design Report for the LCLS-II project has been completed and will be revised based on the new technical parameters. Key design activities, requirements, and high-risk subsystem components will be identified to reduce cost and schedule risk to the project and expedite the startup. The necessary project management systems are fully up-to-date, operating, and are maintained as a SLAC-wide resource.

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[a] FY 2013 funding was requested as a line item construction project, but due to a continuing resolution, the project continued as an MIE.

[b] FY 2013 amounts in the FY 2014 budget request were not shown below the Congressional control level because a full-year appropriation had not yet been enacted when the budget was submitted. TEC, OPC, and TPC totals were based upon the FY 2013 request levels ($63,500,000 TEC and TPC and $0 OPC).

[c] This project has not yet received CD-2 approval; funding estimates are preliminary. Amounts shown include MIE funding of $67,000,000 in the TEC, $18,600,000 in the OPC, and $85,600,000 in the TPC, as detailed in table 5.

SLAC will partner with other SC laboratories for design and procurement of key technical subsystem components. Technical system designs will require research and development activities. Preliminary cost estimates for these systems are based on actual costs from LCLS, to the extent practicable. Recent cost data has been exploited fully in planning and budgeting for the project. Design of the technical systems will be completed by SLAC or partner laboratory staff. Technical equipment will either be fabricated in-house or subcontracted to vendors with the necessary capabilities.

All subcontracts will be competitively bid and awarded based on best value to the government. Project performance metrics for SLAC are included in the M&O contractor's annual performance evaluation and measurement plan.

Lessons learned in the LCLS Project are documented in its project completion report and will be exploited fully in planning and executing LCLS-II.

Biological and Environmental Research

Overview

The mission of the Biological and Environmental Research (BER) program is to support 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 program seeks to understand how genomic information is translated to functional capabilities, enabling more confident redesign of microbes and plants for sustainable biofuels production, improved carbon storage, and understanding the biological transformation of materials such as nutrients and contaminants in the environment. BER research also advances understanding of the roles of the earth's biogeochemical systems (the atmosphere, land, oceans, sea ice, and subsurface) in determining climate in order to predict climate decades or centuries into the future to provide information that will inform plans for future energy and resource needs.

BER research uncovers nature's secrets from the diversity of microbes and plants to understand how biological systems work, how they interact with each other, and how they can be manipulated to harness their processes and products. Starting with the genetic potential encoded by organisms' genomes, BER scientists seek to define the principles that guide the translation of the genetic code into functional proteins and the metabolic and regulatory networks underlying the systems biology of plants and microbes as they respond to and modify their environments.

BER plays a unique and vital role in supporting research on atmospheric processes, climate modeling, interactions between ecosystems and greenhouse gases (especially carbon dioxide [CO_2]), and analysis of impacts and interdependencies of climatic change with energy production and use. BER research addresses the three most important sources of uncertainty in our understanding of the earth's radiant energy balance—clouds, aerosols, and atmospheric greenhouse gases—through coordinated efforts in climate modeling and observation. BER also supports research to understand the impacts of climatic change (e.g., warmer temperatures, changes in precipitation, increased levels of greenhouse gases, and changing distributions of weather extremes) on different ecosystems such as forests, grasslands, and farmland. Finally, BER research seeks understanding of the critical role that biogeochemical processes play in controlling the cycling and mobility of materials (e.g., carbon, nutrients, radionuclides and heavy metals) in the earth's subsurface and across key surface-subsurface interfaces in the environment.

BER's scientific impact has been transformative. Efforts to map the human genome, including the U.S.-supported international Human Genome Project, which DOE formally began in 1990, initiated the era of modern biotechnology and genomics-based systems biology. Today, with its Genomic Sciences activity and the DOE Joint Genome Institute (JGI), BER researchers are using the powerful tools of plant and microbial systems biology to pursue fundamental breakthroughs needed to develop cost-effective cellulosic biofuels. The three DOE Bioenergy Research Centers lead the world in fundamental biofuels-relevant research.

Since the 1950s, BER has been a critical contributor to climate science research in the U.S., beginning with atmospheric circulation studies that were the forerunners of modern climate models. Today, BER research contributes to the Community Earth System Model, a leading U.S. climate model, and addresses two of the most critical areas of uncertainty in contemporary climate science—the impacts of clouds and aerosols—through support of the Atmospheric Radiation Measurement Climate Research Facility (ARM), which is used by hundreds of scientists worldwide. Also, BER has been a pioneer of ecological and environmental studies in terrestrial ecosystems. BER's Environmental Molecular Sciences Laboratory (EMSL) provides the scientific community with powerful suites of instruments and a high performance computer to characterize biological organisms and molecules.

Highlights of the FY 2015 Budget Request

Biological and Environmental Research will support key core research areas and scientific user facilities in bioenergy, climate, and environmental research.

Biological Systems Science

Investments will provide the fundamental biological system science to underpin advances in bioenergy production, carbon cycling in the environment and bioremediation processes. Research targets the development of biosystems design tools and the development of integrative analysis of experimental datasets to examine cross-scale (mesoscale to molecular) relationships among biological processes. Core research in foundational genomics continues for the DOE Bioenergy Research Centers. Genomic Sciences research activities in cellulosic ethanol and biohydrogen are completed, genomics enabled research on carbon cycle processes have been reduced, and the expansion of biodesign enabled biofuels synthesis activities has leveled off. The Mesoscale to Molecules activity will complement and build on successes from the pilot projects initiated in FY 2014 and continue development of new integrative bioimaging technology to translate molecular-scale understanding to systems biology descriptions of cellular and multicellular processes. Activities for human nuclear medicine are completed and radiation studies shift toward linking laboratory-based research with epidemiological research on low dose radiation effects. The Joint Genome Institute (JGI) remains an essential component for DOE systems biology efforts providing high quality genome sequence data and analysis techniques to the research community. JGI's new strategic plan incorporates new capabilities to not only sequence DNA but to interpret, manipulate and synthesize DNA in support of biofuels, biodesign, and environmental research.

Climate and Environmental Sciences

Climate and Environmental Research activities will conduct preliminary scientific analysis of the sensitivity and uncertainty of climate predictions to explore climate sensitive geographies or processes not represented by the Next Generation Ecosystem Experiment (NGEE) Arctic and Tropics studies. New observations of clouds, aerosols, and sensitive ecosystems will address uncertainty in climate models. Increased investment is made to produce an earth system model with improved resolution that will include new codes for running on numerous processors, flexibility toward future computer architectures, and enhanced usability, testing, adaptability, multi-scale treatments, and provenance. The modeling efforts will be validated against new observations. Terrestrial Ecosystem research continues to focus on characterizing the complex interdependent processes and interrelationships between climate change and critical Arctic and tropical ecosystems

ARM continues long-term measurements at fixed sites selected for scientific impact on improving climate models, and the mobile facilities will rotate deployments to three climate-sensitive regions demanding focused and targeted measurements in the Arctic, the tropics, and the Pacific Ocean. ARM will rotate the deployment of the mobile facilities. EMSL undergoes strategic planning to optimize instrument systems available to users in priority biological and environmental molecular sciences, and in preparation for new capabilities in the outyears.

The Data Management effort will focus on a new Climate and Environmental Data Analysis and Visualization activity that will incorporate high resolution earth system models with interdependent components involving energy and infrastructure sector models, field observations, raw data from environmental field experiments, and analytical tools for system diagnostics, validation, and uncertainty quantification.

Biological and Environmental Research
Funding ($K)

	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Biological Systems Science					
Genomic Science					
Foundational Genomics Research	67,588	73,341	73,341	73,228	-113
Genomics Analysis and Validation	10,000	10,000	10,000	10,000	0
Metabolic Synthesis and Conversion	19,887	19,462	19,462	16,262	-3,200
Computational Biosciences	16,395	16,395	16,395	16,395	0
Bioenergy Research Centers	75,000	75,000	75,000	75,000	0
Total, Genomic Science	**188,870**	**194,198**	**194,198**	**190,885**	**-3,313**
Mesoscale to Molecules	**0**	**7,949**	**7,949**	**9,680**	**+1,731**
Radiological Sciences					
Radiochemistry and Imaging Instrumentation	10,000	11,800	11,800	2,665	-9,135
Radiobiology	6,159	3,200	3,200	2,409	-791
Total, Radiological Sciences	**16,159**	**15,000**	**15,000**	**5,074**	**-9,926**
Biological Systems Facilities and Infrastructure					
Structural Biology Infrastructure	13,878	14,895	14,895	14,895	0
Joint Genome Institute	65,000	69,800	69,800	69,500	-300
Total, Biological Systems Facilities and Infrastructure	**78,878**	**84,695**	**84,695**	**84,395**	**-300**
SBIR/STTR	0	9,929	9,929	9,858	-71
Total, Biological Systems Science	**283,907**	**311,771**	**311,771**	**299,892**	**-11,879**
Climate and Environmental Sciences					
Atmospheric System Research	**26,392**	**26,392**	**26,392**	**26,392**	**0**
Environmental System Science					
Terrestrial Ecosystem Science	38,786	45,001	45,001	44,034	-967
Subsurface Biogeochemical Research	23,695	24,033	24,033	25,449	+1,416
Total, Environmental System Science	**62,481**	**69,034**	**69,034**	**69,483**	**+449**
Climate and Earth System Modeling					
Climate Model Development and Validation	0	0	0	29,010	+29,010
Regional and Global Climate Modeling	29,068	28,578	28,578	28,159	-419
Earth System Modeling	35,408	35,569	35,569	35,569	0
Integrated Assessment	8,422	9,853	9,853	9,853	0
Total, Climate and Earth System Modeling	**72,898**	**74,000**	**74,000**	**102,591**	**+28,591**

	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Climate and Environmental Facilities and Infrastructure					
Atmospheric Radiation Measurement Climate Research Facility	68,074	68,429	68,429	68,429	0
Environmental Molecular Sciences Laboratory	44,132	46,700	46,700	45,501	-1,199
Data Management	2,773	3,496	3,496	5,000	+1,504
General Purpose Equipment (GPE)	0	250	250	0	-250
General Plant Projects (GPP)	0	250	250	0	-250
Total, Climate and Environmental Facilities and Infrastructure	**114,979**	**119,125**	**119,125**	**118,930**	**-195**
SBIR/STTR	0	9,374	9,374	10,712	+1,338
Total, Climate and Environmental Sciences	**276,750**	**297,925**	**297,925**	**328,108**	**+30,183**
Total, Biological and Environmental Research	**560,657**	**609,696**	**609,696**	**628,000**	**+18,304**

SBIR/STTR Funding:

- FY 2013 transferred: SBIR $15,613,069; STTR $2,023,916
- FY 2014 projected: SBIR $16,890,000; STTR $2,413,000
- FY 2015 Request: SBIR $18,077,000; STTR $2,493,000

Biological and Environmental Research
Explanation of Major Changes ($K)

	FY 2015 vs. FY 2014 Enacted
Biological Systems Science:	
Foundational genomic research investments in biosystems design, computational biology, and the Bioenergy Research Centers are continued. Targeted research in metabolic synthesis and conversion on cellulosic ethanol and biohydrogen has been completed. Funding for Radiological Sciences decreases as activities are focused on bioenergy and environmental process research. Mesoscale to Molecules research continues development of new integrative bioimaging technology to translate molecular-scale understanding to systems biology descriptions of cellular and multicellular processes. JGI continues to provide DNA sequencing and analysis.	-11,879
Climate and Environmental Sciences: Climate and Earth System Modeling increases with investment in the Climate Model Development and Validation activity that will incorporate finer resolution (less than 10 km) scale-aware physics into climate models not currently available to the community, through a comparison with ARM data and adapting climate model code to make optimal use of current and next-generation high performance computing resources. Terrestrial Ecosystem Science continues, including the Next Generation Ecosystem Experiments (NGEE) Tropics activity. Subsurface biogeochemical research increases to focus on environmental research across scales as a continuum of complex interdependent processes. ARM continues to provide essential cloud and aerosol observations for climate research. Within the Data Management effort, the Climate and Environmental Data Analysis and Visualization activity increases to provide infrastructure that enables database interoperability and visualization. Environmental Molecular Sciences Laboratory (EMSL) funding for operations decreases as facility strategic planning focuses on optimizing instrument systems available to users and planning for new capabilities.	+30,183
Total, Biological and Environmental Research	**+18,304**

Basic and Applied R&D Coordination

BER research underpins the needs of DOE's energy and environmental missions. Basic research on microbes and plants provide fundamental understanding that can be used to develop new bioenergy crops and improved biofuel production processes that are cost effective and sustainable. This research is relevant to other DOE offices and agencies, including DOE's Office of Energy Efficiency and Renewable Energy and the Advanced Research Projects Agency-Energy, and the U.S. Department of Agriculture. Coordination with other federal agencies on priority science needs occurs through the Biomass Research and Development Board, a congressionally mandated interagency group created by the Biomass Research and Development Act of 2000, as amended by the Energy Policy Act of 2005 and the Agricultural Act of 2014, and under the White House Office of Science and Technology Policy (OSTP).

BER research to understand and predict future changes in the earth's climate system provides important tools that link climate predictions to evaluations of new energy policies and help to guide the design criteria for next generation energy infrastructures. An example is the Water-Energy "Tech" Team (WETT) that was created in mid-2013 and brings together the Science, Energy Technology, and Policy Offices of the Department. WETT addresses not only water required for all facets of energy production, from biofuels to thermoelectric cooling, but also the energy required to provide water for various uses. BER research on the transport and transformation of energy-related substances in subsurface environments provides understanding that can enable DOE's Office of Environmental Management (EM) to develop new strategies for the remediation of weapons-related and other contaminants at DOE sites. In general, BER coordinates with DOE's applied technology programs through regular joint program manager meetings, by participating in their internal program reviews and in joint principal investigator meetings, as well as conducting joint technical workshops. Coordination with other federal agencies on priority climate science needs occurs through the interagency U.S. Global Climate Change Research Program under OSTP.

Program Accomplishments

Systems biology for next-generation biofuels. Scientists at the DOE Bioenergy Research Centers (BRCs) are addressing critical barriers to the production of next-generation biofuels from non-food plant biomass. Major recent advances have included the discovery of a new plant gene mediating synthesis of lignin, the component of biomass that is most resistant to deconstruction. Advanced microscopy techniques were used for real time nanoscale imaging of novel cellulose-degrading enzymes attacking biomass in plant cells, allowing researchers to map this process at an unprecedented level of detail. BRC scientists also developed a new genetic tool for high-throughput screening of product synthesis by bioengineered microbes, permitting rapid identification of modified strains producing the largest amounts of biofuels.

Genomics-enabled exploration of soils and the subsurface. The combination of modern -omics approaches, advanced imaging, and computational modeling have led to new discoveries on the bioprocesses of plant roots and microbial communities in soils and the deeper subsurface. BER funded researchers have identified an abundant new class of soil microbes that consume the greenhouse gas nitrous oxide, a discovery with significant implications in predicting climate change impacts and developing sustainable bioenergy systems. The Joint Genome Institute (JGI) recently completed metagenomic sequencing for the root microbiome of the model plant *Arabidopsis thaliana*, an important step toward understanding the coupled processes of plants and associated soil microbes. Collaborating researchers at national laboratories and academic institutions also developed a new computational bioinformatics approach for tracking dynamic changes in subsurface microbial community composition and functional properties related to biogeochemical cycling and contaminant transformation.

Improving Arctic system predictability. The Arctic region is especially sensitive to global change, with sea-ice decline, vegetation shifts, and permafrost degradation. BER research has a growing emphasis on understanding critical Arctic processes and improving their representation in earth system models. This improved representation is generally recognized as a major need for coupled earth system models. Detailed observations of Arctic clouds and aerosols from the ARM site in Barrow, AK have led to significant improvements in how Arctic clouds are represented in the models. The NGEE-Arctic program is improving our understanding and model representation of Arctic soils and permafrost. New representations of high latitude biogeochemistry, carbon fluxes, potential influence of human and natural land use changes, and sea-ice changes have been implemented in the Community Earth System Model. The high-resolution Regional Arctic System Model provides greater detail for many of these Arctic processes.

Mystery of Methylmercury Formation Solved. Methylmercury is a potent neurotoxin, found in many environments contaminated by mercury. It has long been known that inorganic mercury is converted to this toxic form by anaerobic bacteria; however, the genetic mechanism of this transformation had remained unclear. BER-funded scientists combined chemical reasoning with analyses of genome sequence information from two different methylmercury forming bacteria to discover that two genes are required. The identified genes are present in all known mercury-methylating bacteria. The resulting understanding identifies the mechanisms of a fascinating microbial process, informs efforts to detect and manage mercury contamination, and addresses other environmental processes that produce toxic substances.

Biological and Environmental Research
Biological Systems Science

Description

Biological Systems Science integrates discovery- and hypothesis-driven science with technology development on plant and microbial systems relevant to DOE bioenergy mission needs. Systems biology is the multidisciplinary study of complex interactions specifying the function of entire biological systems—from single cells to multicellular organisms—rather than the study of individual components. The Biological Systems Science subprogram focuses on utilizing systems biology approaches to define the functional principles that drive living systems, from microbes and microbial communities to plants and other whole organisms.

Key questions that drive these studies include:

- What information is encoded in the genome sequence?
- How is information exchanged between different subcellular constituents?
- What molecular interactions regulate the response of living systems and how can those interactions be understood dynamically and predictively?

The subprogram builds upon a successful track record in defining and tackling bold, complex scientific problems in genomics—problems that required the development of large tools and infrastructure; strong collaboration with the computational sciences community and the mobilization of multidisciplinary teams focused on plant and microbial bioenergy research. The approaches employed include genome sequencing, proteomics, metabolomics, structural biology, high-resolution imaging and characterization, and integration of information into computational models that can be iteratively tested and validated to advance a predictive understanding of biological systems from molecules to mesoscale.

The subprogram supports operation of a scientific user facility, the DOE Joint Genome Institute (JGI), and use of structural biology facilities through the development of instrumentation at DOE's national user facilities. Support is also provided for research at the interface of the biological and physical sciences and instrumentation for radiochemistry to develop new methods for real-time, high-resolution imaging of dynamic biological processes.

Genomic Science

The Genomic Science activity supports research aimed at identifying the fundamental principles that drive biological systems relevant to DOE missions in energy, climate, and the environment. These principles guide the translation of the genetic code into functional proteins and the metabolic/regulatory networks underlying the systems biology of plants, microbes, and communities. Advancing fundamental knowledge of these systems will enable new solutions to national challenges in sustainable bioenergy production, understanding the fate and transport of materials such as nutrients and contaminants in the environment, and developing new approaches to examine the role of biological systems in carbon cycling, biosequestration, and global climate.

The major objectives of the Genomic Science activity are to determine the molecular mechanisms, regulatory elements, and integrated networks needed to understand genome-scale functional properties of microbes, plants, and communities; develop "-omics" experimental capabilities and enabling technologies needed to achieve a dynamic, system-level understanding of organism and community functions; and develop the knowledgebase, computational infrastructure, and modeling capabilities to advance predictive understanding, manipulation and design of biological systems.

The Systems Biology Knowledgebase (KBase) is an integrated experimental framework for accessing, comparing, analyzing, modeling, and testing large scale Genomic Science data. The team-based multi-institutional DOE Bioenergy Research Centers focus on innovative research to achieve the basic science breakthroughs needed to develop sustainable and effective methods of producing advanced biofuels from cellulosic plant material.

Mesoscale to Molecules

BER approaches to systems biology have focused on the rich terrain between genotype and phenotype—from the genome up through the mechanisms that power living cells, communities of cells, and whole organisms. But there is also a need to explore the terrain between the mesoscale structures within living cells and the molecular effects in biological macromolecules. The Mesoscale to Molecules activity will encourage joint efforts among systems biologists, physical scientists, and engineers, to focus on fostering interdisciplinary approaches and leveraging tools and resources at the national scientific user facilities to improve understanding of the genomic and physical rules that govern the formation, structure, and function of subcellular organelles and their integration within biological systems operating at organism scale.

Radiological Sciences

Radiological Sciences supports radionuclide tracer synthesis and imaging research for real-time visualization of dynamic biological processes in energy and environmentally relevant contexts. The activity has significantly transitioned from its historical focus on nuclear medicine research and applications for human health to focus on real-time, whole organism understanding of metabolic and signaling pathways in plants and nonmedical microbes. Radionuclide imaging continues to be a singular tool for studying living organisms in a manner that is quantitative, three dimensional, temporally dynamic, and non-perturbative of the natural biochemical processes. The instrumentation research focuses on improved metabolic imaging in the living systems, including plants and microbial-communities, relevant to biofuels production and bioremediation of relevance to DOE. The transition from medical imaging application to biofuels and environmental research continues.

The activity also supports fundamental research on integrated gene function and response of biological organisms to low dose radiation exposure, through systems genetics analysis in model systems and epidemiological studies. This activity contributes a scientific foundation for informed decisions regarding remediation of contaminated DOE sites and for determining acceptable levels of human health protection and for both cleanup workers and the public.

Biological Systems Science Facilities and Infrastructure

Biological Systems Science supports unique scientific facilities and infrastructure related to genomics and structural biology that are widely used by researchers in academia, the national laboratories, and industry. The DOE Joint Genome Institute (JGI) is the only federally funded major genome sequencing center focused on genome discovery and analysis in plants and microbes for energy and environmental applications. High-throughput DNA sequencing underpins modern systems biology research, providing fundamental biological data on organisms and groups of organisms. By understanding shared features of multiple genomes, scientists can identify key genes that may link to biological function. These functions include microbial metabolic pathways and enzymes that are used to generate fuel molecules, affect plant biomass formation, degrade contaminants, or capture CO_2, leading to the optimization of these organisms for biofuels production and other DOE missions.

JGI is developing aggressive new strategies for interpreting complex genomes through new high-throughput functional assays, DNA writing and manipulation techniques and, genome analysis tools in association with the DOE Systems Biology Knowledgebase (KBase). These new capabilities are part of JGI's latest strategic plan to provide users with additional capabilities supporting biosystems design efforts for biofuels and environmental process research. JGI also performs metagenome (genomes from multiple organisms) sequencing and analysis from environmental samples and is developing single cell sequencing techniques on hard-to-culture cells from environments relevant to the DOE missions.

BER also supports development and use of specialized instrumentation for biology at major DOE user facilities, such as synchrotron light sources and neutron facilities, in collaboration with the other SC program offices. These research facilities enable science aimed at understanding the structure and properties of biological systems at resolutions and scales not accessible with instrumentation available in university, institute, or industrial laboratories. This information is critical in contributing to our understanding of the relationship between genome, biological structure, and function. BER is also taking steps to ensure that the data will be integrated into the KBase to help accelerate practical applications of this knowledge for energy and the environment.

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Genomic Science		
Continued investments will advance core research areas in Foundational Genomics Research with emphasis on continued development of biosystems design tools and biodesign technologies for bioenergy research, integrative analysis of large experimental genomic science datasets, and efforts to gain a predictive understanding of carbon cycling in the environment. The research portfolio will stress the integration of experimental genome genomic science with computational modeling to advance a predictive understanding of the design, function, and regulation of plants, microbes, and biological communities contributing to the cost-effective production of next generation biofuels as a major secure national energy resource. At least 5% of the funding for biodesign efforts will be used to study the environmental, ethical, legal, and societal impacts. Support will provide for core research activities in plant and microbial systems-level functional genomics and networks, with completion of Metabolic Synthesis and Conversion targeted research on cellulosic ethanol and biohydrogen. Research efforts at the Bioenergy Research Centers will advance biofuels development from foundational biological systems science. Computational Biosciences will advance the DOE KBase effort to develop predictive simulation efforts in plant and microbial community interactions.	Genomic Science research remains a priority activity. Foundational Genomics Research will continue to support development of biosystems design tools and biodesign technologies for plant and microbial systems relevant to bioenergy production, and genomics enabled approaches to examine impacts of bioenergy production and climate change on carbon and nutrient cycling processes in terrestrial ecosystems. At least 5% of the funding for biodesign efforts will be used to study the environmental, ethical, legal, and societal impacts. Genomics Analysis and Validation will integrate experimental biology and technology development to improve functional characterization of genomic datasets. The emphasis of research in Metabolic Synthesis and Conversion will shift to advancing systems biology understanding and developing tools for the genetic modification of a broader set of plant and microbial species relevant to carbon cycling and bioenergy production. Research efforts at the Bioenergy Research Centers will continue to advance biofuels development from foundational biological systems science. Computational Biosciences will continue to support the operation of the DOE KBase, providing the research community with online tools for data integration and predictive modeling and increasing development of interoperable platforms for varying data types and scaling of data environments across multiple levels of biological organization.	Foundational Genomic Research investments in biosystems design will be leveled off and funding for genomics enabled carbon cycle research is decreased. Targeted research in Metabolic Synthesis and Conversion on cellulosic ethanol and biohydrogen has been completed. Genomic Analysis and Validation, the DOE Bioenergy Research Centers, and Computational Biosciences Research continue.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Mesoscale to Molecules		
Research is initiated to understand the genomic and physical rules that govern the formation and architecture of subcellular organelles in biological systems. The relationship between composition and function will be explored, leveraging imaging tools and resources at the national scientific user facilities.	The properties of many complex systems at one observational scale cannot be extrapolated accurately from processes at another scale because the nature of the scaling relationships is unknown. Increased investment will complement pilot projects initiated in FY 2014 and continue efforts to understand the spatial organization of metabolic processes in cells and the physical rules that govern metabolism in subcellular organelles in biological systems. Identifying scaling relationships allows accurate representation of functional relationships within the cell, facilitating improved predictions of multicellular interactions and biological organism behavior with respect to energy and the environment. New modeling concepts will be developed and validated with new imaging tools and resources at the national scientific user facilities and within the DOE KBase.	Emphasis will be placed on integrated experimental and computational approaches to investigate the scaling properties of processes occurring from the molecular to the mesoscale and multicellular organization
Radiological Sciences		
Core research activities will emphasize radiotracer synthetic chemistry for real-time visualization of dynamic biological processes in the energy and environmentally-relevant contexts. Human nuclear medicine research is transitioned to integrative training opportunities in nuclear medicine. Radiobiology research continues to emphasize a systems biology approach to understanding the effects of low dose radiation on cellular processes and epidemiological studies to uncover statistically significant effects of low dose radiation in large populations.	Core activities in Radiochemistry and Imaging Instrumentation will continue to stress development of radiotracer techniques and instrumentation to visualize metabolic processes in plants and microbes non-invasively and in real time. Core efforts in radiobiology will continue to evaluate methods to translate molecular-scale effects of low dose radiation to whole model organisms.	Radionuclide imaging research for real-time visualization of dynamic biological processes in energy and environmentally-relevant contexts continues, while concluding training activities in nuclear medicine research. Decreases in radiobiology reflect a shift towards bioenergy and environmental research within the Biological Systems Science portfolio. Ongoing efforts in radiobiology emphasize a systems biology approach to understanding the subtle effects of low dose radiation on cell processes and epidemiological studies to evaluate statistically significant effects of low dose radiation exposure in large populations.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Biological Systems Science Facilities and Infrastructure		
JGI will emphasize large scale, complex sequencing of plants and microbial communities in support of fundamental research for DOE bioenergy and environmental missions. JGI will facilitate genome science through its massive sequencing capability coupled with high performance computing for data management, integration, and analysis. JGI activities are closely coordinated with DOE's KBase effort and will seek opportunities to integrate high-throughput technologies that can bring added functional understanding to the genome sequences generated. The priority needs for these technologies are informed by the report from the community workshop, "JGI Strategic Planning for the Genomic Sciences," held in FY 2012. JGI sequencing capabilities also support biosystems design efforts.	JGI will maintain its efforts to provide high quality DNA sequence and also bring on new capabilities to interpret, manipulate, and write DNA in support of biofuels, biodesign, and environmental research as part of the implementation of JGIs' new strategic plan. JGI will continue to maintain a close linkage with the DOE KBase allowing the research community to access and analyze the latest genome sequence information produced by JGI.	JGI will increasingly emphasize understanding comparative or community-scale plant and microbial genomics.
Support continues to develop new instrumentation and end stations for structural biology and new research capabilities at the Office of Science synchrotron light sources and neutron facilities.	Support will continue for the instrumentation and end stations for structural biology at the DOE synchrotron light and neutron sources. Additional efforts will be made to link the resulting data from these stations with the DOE KBase.	Support continues for the development of instrumentation at SC's synchrotron light sources, neutron sources, and next-generation user facilities for analyzing biological structure-function relationships.

Description

The Climate and Environmental Sciences subprogram supports fundamental science and research capabilities that enable major scientific developments in climate-relevant atmospheric-process and ecosystem research and modeling, in support of DOE's mission goals for basic science, energy, and national security. This includes research on clouds, aerosols, and the terrestrial carbon cycle; large-scale climate change and earth system modeling; the effects of climate change on ecosystems; and integrated analysis of climate change impacts on energy and related infrastructures. It also supports subsurface biogeochemical research that advances fundamental understanding of coupled physical, chemical, and biological processes controlling the environmental fate and transport of energy byproducts. This integrated portfolio of research from molecular-level to field-scales emphasizes the coupling of multidisciplinary experimentation and advanced computer models and is aimed at developing predictive, systems-level understanding of the fundamental science associated with climate change and other energy-related environmental challenges. The Department will continue to advance the science necessary to further develop predictive climate and earth system models targeting resolution at the regional spatial scale and interannual to centennial time scales and to focus on areas of critical uncertainty including Arctic permafrost thaw and carbon release, in close coordination with the U.S. Global Change Research Program (USGCRP) and the international science community.

The subprogram supports three primary research activities and two national scientific user facilities. The two user facilities are the Atmospheric Radiation Measurements Climate Research Facility (ARM) and the Environmental Molecular Sciences Laboratory (EMSL). ARM provides unique, multi-instrumented capabilities for continuous, long-term observations needed to develop and test understanding of the central role of clouds and aerosols on the earth's climate. EMSL provides integrated experimental and computational resources needed to understand the physical, chemical, and biological processes that underlie DOE's energy and environmental mission.

Atmospheric Systems Research

Atmospheric System Research (ASR) is the primary U.S. activity addressing two major areas of uncertainty in climate change model projections: the role of clouds and the effects of aerosols on precipitation and the atmospheric radiation balance. ASR coordinates with ARM, utilizing the facility's continuous long-term datasets that provide three-dimensional measurements of radiation, aerosols, clouds, precipitation, dynamics, and thermodynamics over a range of environmental conditions at diverse climate-sensitive locations. The long-term observational datasets are supplemented with laboratory studies and shorter-duration ground-based and airborne field campaigns to target specific atmospheric processes under a diversity of locations and atmospheric conditions. ASR research results are incorporated into earth system models developed by Climate and Earth System Modeling to both understand the processes that govern atmospheric components and to advance earth system model capabilities with greater certainty of predictions. ASR seeks to develop integrated, scalable test-beds that incorporate process-level understanding of the life cycles of aerosols, clouds, and precipitation into dynamic models.

Environmental System Science

Environmental System Science supports research to provide a robust, predictive understanding of terrestrial surface and subsurface ecosystems, including the effects of climate change, from the subsurface to the top of the vegetated canopy and from molecular to global scales. This includes understanding the role of ecosystems in climate with an emphasis on carbon cycling and the role of subsurface biogeochemical processes in the fate and transport of carbon, nutrients, radionuclides, and heavy metals.

A significant fraction of the carbon dioxide (CO_2) released to the atmosphere during fossil fuel combustion is taken up by terrestrial ecosystems, but the impacts of climatic change, particularly warming, on the uptake of CO_2 by the terrestrial biosphere remain poorly understood. The significant sensitivity of climate models to terrestrial carbon cycle feedback and the uncertain signs of that feedback make resolving the role of the terrestrial biosphere on the carbon balance a high priority. The research focuses on understanding, observing, and modeling the processes controlling exchange rates of greenhouse gases, in particular CO_2 and methane (CH_4), between atmosphere and terrestrial biosphere, evaluating terrestrial source-sink mechanisms for CO_2 and CH_4, and improving and validating the representation of terrestrial ecosystems in coupled earth system models.

Subsurface biogeochemical research supports integrated research, ranging from molecular to field scales, to understand and predict the role that biogeochemical processes play in controlling the cycling and mobility of energy-relevant materials in the subsurface and across key surface-subsurface interfaces in the environment, including environmental contamination from past nuclear weapons production.

Climate and Earth System Modeling

Climate and Earth System Modeling develops physical, chemical, and biological model components, as well as fully coupled earth system models. This research includes the interactions of human and natural earth systems needed to simulate climate variability and change from years to decades to centuries at regional and global scales. The research specifically focuses on quantifying and reducing the uncertainties in earth system models based on more advanced model development, diagnostics, and climate system analysis. Priority model components include the ocean, sea-ice, land-ice, aerosols, atmospheric chemistry, terrestrial carbon cycling, multi-scale dynamical interdependencies, and dynamical cores.

In FY 2015, BER will initiate a major new investment in Climate Model Development and Validation. The focus of the investment will be on restructuring model architecture, exploiting new software engineering and computational upgrades, and incorporating scale-aware physics in all model components. In addition, new DOE modeling activities will be based on modularized components that can act either alone or as a system, thus allowing greater certainty of predictions in a flexible structure. The BER climate modeling activities will produce earth system model codes that will run optimally on current and next-generation supercomputers with numerous processors. Also, this effort will consider algorithm and code design in conjunction with architecture evolution, for co-design and next generation computation. This capability will enable BER to produce earth-system models with improved resolution that are compatible with near-term and next generation computing hardware. Advanced code engineering enhances usability, testing for performance and accuracy, and also for validation with respect to ARM observations and data. Work will begin to develop workflows that automate comparison of model with diverse measurements (satellite, ground-based, and radar measurements), to provide analysis platforms, including methods to characterize and bound projection uncertainty. Because model development requires systematic validation along each step, the increased investments in model validation will use the three dimensional ARM data available from both fixed and mobile field platforms. The model development activities will focus on the rapid development and use of more efficient representations of scale-aware atmospheric parameters in earth systems models. This will improve climate predictability from hydrostatic (currently at 10 km resolution) to nonhydrostatic physics (at resolutions finer than 10 km). Advances in ARM measurement capabilities and DOE computing capability/modeling resolution will allow ARM data to be used to validate climate models under a variety of conditions and regions, providing high resolution model testbeds. This validation activity will focus on three critical areas:

- Developing methodologies to produce high resolution data sets enabling ARM data to be assimilated into advanced sub-grid scale model elements that extend resolutions below 10 km. This effort will be developed to exploit data from each ARM fixed facility and will be a component of each mobile facility deployment—providing unique and specialized testbeds for model improvement and validation based on recent ARM enhancements.
- Simultaneous ARM deployment and downscaling research embedded within the 10 km footprint of ARM observations.
- The high resolution ARM and model ensemble data bases will be integrated into the advanced data management infrastructure effort, Climate and Environmental Data Analysis, and Visualization activity, for use by the scientific research community.

The Regional and Global Climate modeling activity continues to provide scientific analyses using DOE's investments in climate and earth system model development. Scientific analyses will study the predictability of statistical distributions of future weather extremes; causes and distributions of droughts; biogeochemical controls on abrupt climate change; the role of the highly resolved patterns of carbon budgets on regional and global climate change; and the roles of cryospheric phenomena (sea ice, glaciers, ice sheets, and permafrost thaw) on Arctic climate, sea level rise, and large scale modes of variability. Also, new research will explore model derived analogs that combine historical and projected climate changes, with an objective to validate and improve the uncertainty characterization of future climate projections based on the prediction successes using existing data testbeds. To rapidly and efficiently advance model capabilities, BER supports a unique and powerful intercomparison resource, the Program for Climate Model Diagnosis and Intercomparison (PCMDI), for global climate model development, validation, diagnostics, and outputs, using over 40 world-leading climate models. This set of diagnostic and intercomparison activities combined with scientific analysis, ensures BER funded researchers can exploit the best available science and practice within each of the world's leading climate research programs.

The Earth System Modeling activity in BER will continue to coordinate with the National Science Foundation (NSF) to provide support for the Community Earth System Model system (CESM). CESM is designed by the research community with open access and broad use by climate researchers worldwide. This system of models provides a critical capacity for regional climate projections, including information on how the frequency of occurrence and intensity of storms, droughts, and heat waves will change as climate evolves. The scientific priorities for improvement of the community model system are based on efforts to quantify uncertainties relative to specific scientific questions; and the outputs of the intercomparison and validation resource allow one to determine best features of all global models that can be considered for incorporation into DOE's modeling platform. DOE has also provided computational power and expertise to the climate research community through a partnership between BER and the Office of Science's Advanced Scientific Computing Research (ASCR) program, which is innovating code design for optimal model computation on its petascale computers. Climate modeling tools are essential for informing investment decision-making processes for infrastructures associated with future large-scale deployment of energy supply and transmission.

The Integrated Assessment activities in BER continue to support the development of integrated assessment model components to the DOE Earth System Modeling activities, with a focus on assessing the interdependencies of energy, water, and land sector activities that are coupled to the physical and biogeochemical drivers of climate and earth system change. The investments will address uncertainty characterization of both the individual physical, biogeophysical, and sectorial (including energy infrastructure as well as emerging clean energy technology deployment) drivers, extending from macroscale (greater than 50 km resolution) to the much finer scales of earth system prediction (order of 10 km). Interdependencies, feedbacks, scale aware predictions, and uncertainty characterization will be broadly developed to support the DOE mission.

Climate and Environmental Facilities and Infrastructure

Climate and Environmental Facilities and Infrastructure include two scientific user facilities, and climate data management for the climate science community. The scientific user facilities—the Atmospheric Radiation Measurement Climate Research Facility (ARM) and the Environmental Molecular Sciences Laboratory (EMSL)—provide the broad scientific community with technical capabilities, scientific expertise, and unique information to facilitate science in areas integral to BER's mission.

ARM is a multi-platform multi-site national scientific user facility, providing the world's most comprehensive continuous field measurements of climate data to advance atmospheric process understanding and climate models through precise observations of atmospheric phenomena. ARM currently consists of four fixed long-term measurement facility sites (in Oklahoma, Alaska, the Azores, and the western tropical Pacific (to be closed in late 2014)), three mobile facilities, and an airborne research capability that operates at sites selected by the scientific community. The ARM fixed sites and mobile measurement campaigns are distributed around the world in locations where the scientific community most critically needs enhanced understanding and data to incorporate into climate models, thereby improving model performance and predictive capabilities. Each of the ARM sites includes scanning radars, lidar systems, and in situ meteorological observing capabilities; the sites are additionally used to demonstrate technologies as they are developed by the community. ARM experiments to study the impact of evolving clouds, aerosols, and precipitation on the earth's radiative balance and rate of climate change address the two most significant scientific uncertainties in climate research. Also, BER is maintaining the exponentially increasing data archive to support enhanced analyses and model development. The data extracted from the archive are used to improve climate projections at higher resolution, greater sophistication, and lower uncertainty.

EMSL provides integrated experimental and computational resources for discovery and technological innovation in the environmental molecular sciences. With more than more than 75 premier instruments as well as a high performance computer and associated software, EMSL enables users to undertake molecular-scale experimental and theoretical research on biological systems, biogeochemistry, aerosol chemistry, and interfacial and surface science relevant to climate, energy, and environmental challenges facing DOE and the Nation. This includes science supporting alternative energy sources, improved catalysts and materials for industrial applications, insights into factors influencing climate change and carbon sequestration processes, and subsurface biogeochemical drivers.

Data sets generated by ARM, other DOE and Federal earth observing activities, and earth system modeling activities, are large. The information in earth observations data can be used to achieve broad benefits ranging from planning and development of energy infrastructure to natural disaster impact mitigation to commercial supply chain management to natural resource management. Access to and uses of these data are fundamental to supporting decision-making, scientific discovery, and technological innovation. DOE's data management activities will be coordinated with the Big Data Research and Development Initiative (http://www.whitehouse.gov/sites/default/files/microsites/ostp/big_data_press_release_final_2.pdf), that in turn involves two important processes for the earth observation community, the civil Earth Observation Assessment (EOA) and the Big Earth Data Initiative (BEDI), both which are overseen by the newly chartered U.S. Group on Earth Observations (USGEO) Subcommittee of the Committee on Environment, Natural Resources, and Sustainability. BER's data investments are internally collaborative with the Advanced Scientific Computing Research program.

In FY 2015, the BER Data Management effort includes the Climate and Environmental Data Analysis and Visualization activity that focuses on combining ensembles of new generations of adaptive grid high resolution earth system prediction models with interdependent components involving energy and infrastructure sector models, field observations from ARM, the AmeriFlux Network, ongoing and planned NGEE projects, raw data from environmental field experiments, and analytical tools for system diagnostics, validation, and uncertainty quantification.

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Atmospheric System Research		
ASR focuses on process studies and modeling efforts that improve formulations of aerosols, mixed phase clouds, and precipitation process interdependencies, in order to improve estimates of feedbacks on climate in mid-latitude, tropical, and Arctic regions. Specific focuses include the description of aerosol-cloud-precipitation interdependences during larger scale dynamical events, such as those that occur in the tropics and mid-latitudes.	ASR will continue to focus on highest priority areas of uncertainty in climate projections—the behavior and function of clouds and aerosols and their role in controlling the atmospheric radiation balance.	Research will continue to improve formulations for aerosols, clouds, and aerosol-cloud-precipitation interactions in order to improve estimates of how these feedbacks have and will impact climate.
Environmental System Science		
The research will emphasize the Arctic and tropics Next Generation Ecosystem Experiments (NGEE) and AmeriFlux to improve the representation of the major carbon sinks associated with changing climates. Specific NGEE Tropics field studies will be conducted based on the recommendations provided during the NGEE Tropics Workshop held in FY 2012. Support for terrestrial modeling activities will be shifted to the Climate and Earth System Modeling portfolio to promote stronger model research coordination and cost efficiencies. In addition, efficiency will be gained by consolidating investments in terrestrial and subsurface biogeochemistry, nutrient flow, and soil science.	Research continues to understand and predict the roles of terrestrial ecosystems in the larger earth system. NGEE Arctic will begin the transition to Phase II of the project, building from three years of field sampling and process modeling at the Barrow site for Phase I and extending to seven additional years of multiple site sampling, multiple site process modeling, and dynamic model integration into regional climate simulations for Phase II. NGEE Tropics continues with investments to carefully connect field and modeling activities. AmeriFlux will emphasize efforts to encourage common practices and protocols across the network. Subsurface biogeochemistry will continue to focus on fundamental processes that control the fate and transport of energy-related materials in the subsurface.	The activity will provide continued support for understanding and modeling Arctic and tropical carbon vulnerability and will support experimental field activities at the NGEE Tropics to study and contribute to predictive models that characterize the relationships between various tropical ecosystems and climate change. Subsurface biogeochemical research continues to focus on environmental research across scales as a continuum of complex interdependent processes, increasing integration of subsurface modeling and process research.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Climate and Earth System Modeling		
Research on climate model development and analysis focuses on the science underpinning high-resolution predictability using adaptive grids and uncertainty characterization. Emphasis is placed on regional predictions for the Arctic and tropics that map into extended Community Land Model capabilities using data from the NGEE experiments. In addition, understanding dynamical interdependencies that describe larger scale variabilities (such as El Niño) that influence regional climate predictability is prioritized.	Climate Model Development and Validation advanced software and improved algorithms for DOE Climate Modeling will lead to major improvements to earth system model code that is designed to run optimally on next-generation supercomputers with numerous processors. Investments in scale-aware parameterizations, multi-component uncertainty characterization, and modularized model system components will additionally allow the transition of climate predictions to extend to finer resolutions, (below 10 km) with improved predictability. In order to systematically validate model developments at each step of the process, Climate Model Development and Validation using ARM data will be based on three-dimensional testbeds that will be developed and incorporated into the model development agenda. Testbeds will be based on recent advances in ARM data resolution to produce high resolution three-dimensional data sets enabling assimilation into advanced sub-grid scale model elements. Research on climate model development and analysis continues to focus on the science underpinning high-resolution predictability using adaptive grids and uncertainty characterization—both of which are challenging and long-term needs for the community. Emphasis continues on land and atmosphere modeling investments that parallel and connect with investments in the process research aspects of the subprogram.	Emphasis in the first year of activities for Climate Model Development and Validation will be on initiating the activity that combines advanced software code development and numerical methods with new ARM data testbeds that in turn will produce new conceptual designs for a next generation earth system prediction model platform. The model development and procedures for code development and testing will additionally incorporate adaptive and modular architectures, with multi-scale treatments and provenance. Efforts will focus on initiating the activity and developing three-dimensional ARM testbeds that will be systematically incorporated into the model development process. In addition, downscaling of model resolution to be compatible with high resolution observational data sets will be studied to advance predictability to resolutions below 10 km.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
	Core research in Regional and Global Climate Modeling, Earth System Modeling and Integrated Assessment continues to underpin high-resolution predictability using adaptive grids and uncertainty characterization.	Investments continue to evolve climate modeling capabilities using more flexible and adaptive software to support new physics and be compatible with next generation high performance computing assets. Basic research will focus on the science underpinning high-resolution predictability and uncertainty quantification using adaptive grids.
Climate and Environmental Facilities and Infrastructure		
ARM will fully support its long-term measurements at fixed sites, and the mobile facilities will be deployed to three climate-sensitive regions demanding targeted measurements: the Amazon Basin; Oliktok, Alaska; and Finland. These observations are key to reducing the earth system model uncertainties attributed to clouds and aerosols. The ARM fixed site in the Tropical Western Pacific (TWP) will be closed in late 2014; instrumentation from this site will be assimilated into the fixed site at the Southern Great Plains (SGP) (Oklahoma).	ARM will continue to support its long-term measurements at fixed sites, and the mobile facilities will be deployed to three climate-sensitive regions demanding targeted measurements. The first mobile facility will remain in the Amazon Basin; the second will be deployed on the NOAA ship Ron Brown for a campaign in the Pacific Ocean; the third will continue the experiment in Oliktok, Alaska. These observations are key to reducing the earth system model uncertainties attributed to clouds and aerosols.	Funding continues for ARM. Users may be reduced during the relocation of instrumentation from TWP to SGP.
EMSL will support facility operations that underpin user research to obtain a fundamental understanding of the physical, chemical, and biological processes that map to DOE mission needs. New capabilities of the Radiological Annex, including x-ray photo emission spectrometers, electron microscopy, electron probe microanalyzer, transmission electron microscopy, and scanning electron microscopy, come on line in FY 2014 to study contaminated materials and examine radionuclides and chemical signatures. All components of the High Resolution and Mass Accuracy Capability (HRMAC) will be integrated into the complete system.	EMSL continues to support users and their research in biological systems, biogeochemistry, aerosol chemistry, and interfacial and surface science relevant to climate, energy, and environmental challenges facing DOE and the Nation. Emphasis will be placed on utilization of new capabilities in the Radiological Annex and Quiet wing. In FY 2015 the integrated HRMAC system will be tested to meet specifications, and procedures will be developed for user operations. EMSL will develop a plan for targeting and attracting users for the new capability.	EMSL funding for operations decreases with prioritization of instrument systems available to users.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
BER will participate in the Big Earth Data Initiative to adapt the ARM data archive and other DOE earth data sets to specifications aimed at increasing interoperability and compatibility with the needs of the scientific community. In addition, ARM will continue to format its databases in order to conform to the needs of the evolving climate modeling community.	The Climate and Environmental Data Analysis and Visualization activity combines high resolution earth system models with interdependent components involving energy and infrastructure sector models, field observations, raw data from environmental field experiments, and analytical tools for system diagnostics, validation, and uncertainty quantification. Existing data management activities are combined with new capabilities to create this Climate and Environmental Data Analysis and Visualization activity which will integrate and add value to the subprogram's high resolution modeling needs and output, expanding observational data sets and extensive data from field and laboratory experiments and observations. Participation in the Big Earth Data Initiative continues.	Emphasis for this year will be on assembling and making available existing data sets, cataloging user needs from process and modeling communities and developing mechanisms to meet those needs.
General Plant Projects (GPP) and General Purpose Equipment (GPE) are provided for Oak Ridge Institute for Science and Education (ORISE).	In FY 2015, ORISE GPP/GPE is transferred to the Science Laboratories Infrastructure program.	N/A

Biological and Environmental Research
Performance Measures

In accordance with the GPRA Modernization Act of 2010, the Department sets targets for, and tracks progress toward, achieving performance goals for each program. For more information, refer to the Department's FY 2013 Annual Performance Report. The following table shows the targets for FY 2013 through 2015.

	FY 2013	FY 2014	FY 2015
Performance Goal (Measure)	**BER Climate Model—Develop a coupled climate model with fully interactive carbon and sulfur cycles, as well as dynamic vegetation to enable simulations of aerosol effects, carbon chemistry, and carbon sequestration by the land surface and oceans and the interactions between the carbon cycle and climate**		
Target	Use new climate model simulations to quantify interactions between clouds and climate changes	Use global models to estimate most sensitive elements of terrestrial carbon to climate change for tropics, mid-latitudes, and polar regions	Develop capabilities to extend temporal resolution to sub-decadal for earth system models.
Result	Met	Not Applicable	Not Applicable
Endpoint Target	BER supports the Community Earth System Model, a leading U.S. climate model, and addresses two of the most critical areas of uncertainty in contemporary climate science—the impacts of clouds and aerosols. Delivery of improved scientific data and models (with quantified uncertainties) about the potential response of the earth atmosphere system to more accurately predict the earth's future climate is essential to plan for future energy needs, water resources, and land use. DOE will continue to advance the science necessary to further develop predictive climate and earth system models at the regional spatial scale and decadal to centennial time scales, involving close coordination with the U.S. Global Change Research Program and through the international science community.		

	FY 2013	FY 2014	FY 2015
Performance Goal (Measure)	**BER Predictive Understanding of Biological Systems—Advance an iterative systems biology approach to the understanding and manipulation of plant and microbial genomes as a basis for biofuels development and predictive knowledge of carbon and nutrient cycling in the environment.**		
Target	Not Applicable	Not Applicable	Develop 1 new computationally enabled approach to analyze complex genomic datasets.
Result	Not Applicable	Not Applicable	Not Applicable
Endpoint Target	BER will advance understanding of the operating principles and functional properties of plants, microbes, and complex biological communities relevant to DOE missions in energy and the environment. Deciphering the genomic blueprint of organisms and determining how this information is translated to integrated biological systems permits predictive modeling of bioprocesses and enables targeted redesign of plants and microbes. BER research will address fundamental knowledge gaps and provide foundational systems biology information necessary to advance development of sustainable bioenergy systems and predict impacts of changing environmental conditions on carbon cycling and other biogeochemical processes.		
Performance Goal (Measure)	**BER Facility Operations—Average achieved operation time of BER user facilities as a percentage of total scheduled annual operation time**		
Target	≥ 98%	≥ 98%	≥ 98%
Result	Met	Not Applicable	Not Applicable
Endpoint Target	Many of the research projects that are undertaken at the Office of Science's scientific user facilities take a great deal of time, money, and effort to prepare and regularly have a very short window of opportunity to run. If the facility is not operating as expected the experiment could be ruined or critically setback. In addition, taxpayers have invested millions or even hundreds of millions of dollars in these facilities. The greater the period of reliable operations, the greater the return on the taxpayers' investment.		

Biological and Environmental Research
Capital Summary ($K)

	Total	Prior Years	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Capital Operating Expenses Summary							
Capital equipment projects under $2 million TEC	n/a	n/a	3,131	6,217	6,217	4,667	-1,550
General plant projects (GPP) under $5 million TEC	n/a	n/a	0	250	250	0	-250
Total, Capital Operating Expenses	**n/a**	**n/a**	**3,131**	**6,467**	**6,467**	**4,667**	**-1,800**

Funding Summary ($K)

	FY 2013 Current	FY 2014 Enacted	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Research	369,573	390,069	409,105	+19,036
Scientific user facilities operations and research	191,084	199,824	198,325	-1,499
Major items of equipment	0	0	0	0
Other[a]	0	19,803	20,570	+767
Total, Biological and Environmental Research	**560,657**	**609,696**	**628,000**	**+18,304**

Facility Operations ($K)

	FY 2013 Current	FY 2014 Enacted	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Structural Biology Infrastructure[b]	$13,878	$14,895	$14,895	$0
Joint Genome Institute	$65,000	$69,800	$69,500	-$300
Achieved operating hours	8,760	N/A	N/A	
Scheduled operating hours	8,760	8,585	8,616	+31
Optimal hours	8,760	8,616	8,616	0
Percent of optimal hours	100.0%	99.6%	100.0%	
Unscheduled downtime hours	0	N/A	N/A	
Number of users	1,155	1,000	1,000	0

[a] Includes SBIR, STTR, GPE, and non-Facility related GPP.

[b] Structural Biology Infrastructure activities are at Basic Energy Sciences user facilities and the user statistics are included in the BES user statistics.

	FY 2013 Current	FY 2014 Enacted	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Atmospheric Radiation Measurement Climate Research Facility (ARM)	$68,074	$68,429	$68,429	0
Achieved operating hours	7,979	N/A	N/A	
Scheduled operating hours	7,906	7,906	7,906	0
Optimal hours	7,906	7,906	7,906	0
Percent of optimal hours	100.9%	100.0%	100.0%	
Unscheduled downtime hours	0	N/A	N/A	
Number of users	983	1,000	900	-100
Environmental Molecular Sciences Laboratory	$44,132	$46,700	$45,501	-$1,199
Achieved operating hours	4,281	N/A	N/A	
Scheduled operating hours	4,272	4,272	4,272	0
Optimal hours	4,272	4,272	4,272	0
Percent of optimal hours	100.2%	100.0%	100.0%	
Unscheduled downtime hours	0	N/A	N/A	
Number of users	750	750	750	0
Total Facilities	$191,084	$199,824	$198,325	-$1,499
Achieved operating hours	21,020	NA	NA	
Scheduled operating hours	20,938	20,763	20,794	+31
Optimal hours	20,938	20,794	20,794	0
Percent of optimal hours (funding weighted)	100.4%	99.9%	100.0%	0
Unscheduled downtime hours	0	N/A	NA	
Number of users	2,888	2,750	2,650	-100

Scientific Employment

	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	FY 2015 vs. FY 2014
Number of permanent Ph.D.'s	1,428	1,290	1,375	+85
Number of postdoctoral associates	316	315	335	+20
Number of graduate students	461	400	465	+65

Fusion Energy Sciences

Overview

The Fusion Energy Sciences (FES) program mission is to expand the fundamental understanding of matter at very high temperatures and densities and to build the scientific foundation needed to develop a fusion energy source. This is accomplished through the study of plasma, the fourth state of matter, and how it interacts with its surroundings.

Understanding the scientific character of the burning plasma state, as well as establishing the science for maintaining this state for long durations, is a major objective of FES research. To achieve these research goals, FES invests in flexible U.S. experimental facilities of various scales, international partnerships leveraging U.S. expertise, large-scale numerical simulations based on experimentally validated theoretical models, the development of advanced fusion-relevant materials, and the invention of new measurement techniques.

The knowledge base being established through FES research supports U.S. goals for future scientific exploration on ITER,[a] a major international fusion facility currently under construction in Caderache, France. If successful, ITER will be the world's first magnetic-confinement burning plasma experiment aimed at demonstrating the scientific and technical feasibility of fusion as a future energy source. Execution and oversight of the U.S. contribution to the ITER project are carried out within FES.

FES also supports discovery plasma science, including research in plasma astrophysics, small-scale magnetic confinement experimental platforms, and high energy density laboratory plasmas. Some of this work is jointly supported with the National Science Foundation.

Highlights of the FY 2015 Budget Request

The most notable changes in the FY 2015 budget include:

- *Increased support for collaboration in the DIII-D and NSTX-U national research programs*—Research funding is increased to make it possible for more scientists, graduate students, and post docs from universities and national laboratories to collaborate in the scientific programs at the DIII-D and NSTX-U user facilities. Areas of emphasis, all critically important for ITER operation, include boundary and pedestal physics, radio-frequency current drive and heating techniques, magneto-hydrodynamic stability and disruption studies, core transport physics, and advanced diagnostic systems.
- *Increase for NSTX-U research and operations*—With the completion of the upgrade project and the resumption of experimental operations in early FY 2015, funding for NSTX-U operations is increased to support 18 weeks of run time and to begin design and fabrication of two important facility enhancements—a divertor cryo-pump for better control of plasma density and a set of magnetic control coils to improve stable, high-performance operation. NSTX-U research funding is also increased to restore the number of PPPL researchers to pre-upgrade levels (since some resources had been shifted from research to the upgrade project).
- *Progress in hardware contributions for U.S. ITER Project*—Funding provided for critical path items will ensure that U.S. in-kind contributions maintain U.S. commitment to FY 2015 project needs. Funding is provided for ITER Project Office operations; the U.S. cash contribution; and continued progress on in-kind contributions, including industrial procurements of central solenoid magnet modules and structures, toroidal field magnet conductor fabrication, diagnostics, and tokomak cooling water system procurement.

[a] The name ITER is adapted from an acronym for International Thermonuclear Experimental Reactor, which was used for an earlier version of the project.

Fusion Energy Sciences
Funding ($K)

	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Fusion Energy Sciences					
DIII-D Research	32,617	30,998	30,998	32,038	+1,040
Alcator C-Mod Research	8,021	7,890	7,890	6,145	-1,745
International Research	10,132	9,954	9,954	8,545	-1,409
Diagnostics	3,539	3,500	3,500	3,575	+75
Other	4,408	11,562	11,562	2,508	-9,054
NSTX Research	18,316	22,056	22,056	26,000	+3,944
Experimental Plasma Research	10,480	10,500	10,500	10,750	+250
High Energy Density Laboratory Plasmas	17,295	17,315	17,315	6,700	-10,615
Madison Symmetric Torus	5,750	5,700	5,700	5,900	+200
Theory	23,051	24,029	24,029	21,170	-2,859
SciDAC	6,556	9,375	9,375	7,000	-2,375
General Plasma Science	13,456	15,000	15,000	15,500	+500
SBIR/STTR	0	8,797	8,797	8,490	-307
Subtotal, Fusion Energy Sciences	**153,621**	**176,676**	**176,676**	**154,321**	**-22,355**
Facility Operations					
DIII-D	31,461	43,960	43,960	37,385	-6,575
Alcator C-Mod	8,656	14,050	14,050	11,855	-2,195
NSTX	35,093	40,300	40,300	37,354	-2,946
Other, General Purpose Equipment (GPE), and General Plant Projects (GPP)	1,525	5,900	5,900	3,125	-2,775
MIE: U.S. Contributions to ITER Project	124,000	0	0	0	0
Total, Facility Operations	**200,735**	**104,210**	**104,210**	**89,719**	**-14,491**
Enabling R&D					
Plasma Technology	10,686	12,922	12,922	11,910	-1,012
Advanced Design	1,231	1,400	1,400	1,500	+100
Materials Research	11,503	9,969	9,969	8,550	-1,419
Total, Enabling R&D	**23,420**	**24,291**	**24,291**	**21,960**	**-2,331**

	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Construction					
14-SC-60 ITER	0	199,500	199,500	150,000	-49,500
Total, Fusion Energy Sciences	**377,776**	**504,677**	**504,677**	**416,000**	**-88,677**

SBIR/STTR:

- FY 2013 transferred: SBIR: $6,516,000; STTR: $845,000
- FY 2014 projected: SBIR $7,697,000 and STTR $1,100,000
- FY 2015 Request: SBIR: $7,461,000; STTR: $1,029,000

Fusion Energy Sciences
Explanation of Major Changes ($K)

	FY 2015 vs. FY 2014 Enacted
Science: Research funding is increased for NSTX-U and DIII-D, including more support for outside university and national laboratory collaborations on these facilities.	-22,355
Facility Operations: Facility operations funding is increased for NSTX-U; this increase is offset by a reduction in MIE funding.	-14,491
Enabling R&D: No major changes.	-2,331
Construction: Funding provided for critical path items will ensure that U.S. in-kind contributions to ITER maintain U.S. commitment to FY 2015 project needs.	-49,500
Total Funding Change, Fusion Energy Sciences	**-88,677**

Basic and Applied R&D Coordination

FES carries out a discovery-driven plasma science research program in concert with the National Science Foundation (NSF), with research extending to a wide range of natural phenomena, including the origin of magnetic fields in the universe and the heating of the solar corona. FES also operates a joint program with the National Nuclear Security Administration (NNSA) in High Energy Density Laboratory Plasma (HEDLP) physics. Both programs involve coordination of solicitations, peer reviews, and workshops. The Fusion Energy Sciences Advisory Committee (FESAC) provides technical and programmatic advice to FES and NNSA for the joint HEDLP program.

Program Accomplishments

ITER component production underway; first major deliveries made—The U.S. ITER Project completed production of all superconducting strands for the toroidal field magnets and made the first deliveries of the vacuum auxiliary system to the ITER Organization. On-going fabrication of the massive, nuclear facility-grade tokamak cooling water system drain tanks is on schedule consistent with installing components within the tokamak building in 2014.

Advanced method to accelerate data-intensive fusion applications wins a 2013 R&D 100 Award—A research team led by an Oak Ridge National Laboratory (ORNL) scientist jointly supported by FES and Advanced Scientific Computing Research (ASCR) developed the *Adaptable Input/Output System* (ADIOS), which significantly increases the performance of massively parallel codes. The ADIOS software improved the performance of fusion codes by more than an order of magnitude on the Office of Science leadership computing resources.

New measurement techniques allow two-dimensional plasma imaging—Standard methods for measuring plasma temperature and density and their fluctuations have long relied on a single line of sight, providing only a one-dimensional profile. Several newly developed techniques are now able to image the temperature and density variations over a two-dimensional (2-D) plasma cross-section. The 2-D imaging measurements enhance our understanding of how plasma transport due to fluctuations and turbulence can affect particle and energy confinement in fusion plasmas.

Birth of turbulent blobs at the edge of tokamak plasma—Understanding the turbulence at the plasma edge is critical since it controls how well particles and heat are confined across the last closed magnetic surfaces in fusion plasmas. Marking a significant advance over earlier fluid-model descriptions, new large-scale simulations with a gyrokinetic code that follows behavior in five-dimensional position and velocity space have been able to analyze how experimentally observed “blobs,” large-amplitude near-coherent structures that move radially outward at the edge, are born and propagate.

Catch and suppress capability demonstrated for plasma instabilities—Localized current driven by electron cyclotron frequency waves applied to a plasma can suppress the formation of the Neoclassical Tearing Mode, a plasma instability that, if it grows unabated, can eventually trigger a full-scale disruption. Recently this capability was greatly enhanced through development of an advanced real-time feedback control system that can rapidly aim the current at exactly the right spot to shrink the modes.

Description

The Science subprogram advances the predictive understanding of plasma confinement, dynamics, and interactions with surrounding materials. The greatest emphasis is on understanding magnetically confined fusion-grade plasmas; however, FES also stewards discovery-oriented research in the broader plasma sciences. Among the activities supported by this subprogram are:

- Research at major experimental facilities aimed at resolving fundamental fusion plasma science issues, including developing the predictive understanding needed for ITER operations, and providing solutions to high-priority ITER concerns.
- Research on small- and medium-scale magnetic confinement experiments to elucidate physics principles underlying toroidal confinement and to validate theoretical models and simulation codes.
- Research performed at a new generation of international fusion research facilities to exploit their unique capabilities and characteristics, especially in areas to accelerate progress at these experiments.
- Theoretical work on the fundamental description of magnetically confined plasmas and the development of advanced simulation codes on current and emerging high-performance computers.
- Development of unique measurement capabilities and diagnostic instruments to enable experimental validation and provide tools for feedback control of fusion devices.
- Research addressing fundamental scientific questions on high energy density laboratory plasmas, through experimental, theoretical, and modeling efforts.
- Research advancing basic understanding of the broad, multidisciplinary field of general plasma science, which has far-reaching impacts, from developing new products through low-temperature plasmas to understanding exotic phenomena in the cosmos.

DIII-D Research

The DIII-D research program is carried out on the DIII-D tokamak at General Atomics in San Diego, California—the largest magnetic fusion facility in the U.S.

The DIII-D research goal is to establish the scientific basis to optimize the tokamak approach to magnetic confinement fusion. Much of this research concentrates on developing the advanced tokamak concept, in which active control techniques are used to manipulate and optimize the plasma to obtain conditions scalable to robust operating points and high fusion gain for ITER and future fusion reactors. Near-term targeted efforts address scientific issues important to the ITER design. Longer-term research focuses on advanced scenarios to maximize ITER performance. Another high-priority DIII-D research area is foundational fusion science, pursuing a basic scientific understanding across all fusion plasma topical areas.

Alcator C-Mod Research

The Alcator C-Mod tokamak is a compact device employing intense magnetic fields to confine high-temperature, high-density plasmas in a small volume. Housed at the Massachusetts Institute of Technology, the program is operated as a national scientific user facility. Key research areas are disruption mitigation, radio-frequency heating and current drive science, plasma edge physics, and plasma-material interactions. C-Mod research is organized around integrated operating scenarios at plasma conditions relevant to fusion energy production.

International Research

In addition to their work on domestic facilities, U.S. researchers participate in experiments at international facilities that leverage U.S. strengths. Such participation enables U.S. researchers to pursue fusion science not accessible in the U.S. Examples are collaborations on facilities in China (Experimental Advanced Superconducting Tokamak [EAST]), Korea (Korean Superconducting Tokamak Advanced Research [KSTAR]), United Kingdom (Joint European Torus), Germany (Wendelstein 7-X), and Japan (Large Helical Device).

Diagnostics

Diagnostics, the scientific instruments used to make detailed measurements of the behavior of plasmas, are key to advancing our ability to predict and control the behavior of fusion plasmas. Diagnostics are also an excellent vehicle to involve the university and industrial communities in fusion research on major facilities and international collaboration as the FES program advances into the burning plasma era. This program activity focuses on the development of new and innovative diagnostic techniques; the implementation of mature diagnostics systems is supported via the research programs at the major facilities.

Other

Funding in this category supports activities including research at Historically Black Colleges and Universities (HBCUs), the U.S. Burning Plasma Organization (a national organization that coordinates research in burning plasma science), peer reviews for solicitations across the program, and the Fusion Energy Sciences Advisory Committee (FESAC).

NSTX Research

The National Spherical Torus Experiment Upgrade (NSTX-U) is a national scientific user facility designed to explore the physics of plasmas confined in a spherical torus (ST) configuration. Research on this configuration could lead to the development of smaller and more economical future fusion research facilities. The ST configuration, with its very strong magnetic curvature, has different confinement and stability properties from those of conventional tokamaks. A major upgrade, currently in progress, will increase the plasma current and magnetic field capabilities of the facility by a factor of two and increase its pulse length from 1 second to 5 seconds.

Experimental Plasma Research

Experimental Plasma Research (EPR) provides data in regimes of relevance to the FES mainline magnetic confinement and materials science efforts and helps confirm theoretical models and simulation codes in support of the FES goal to develop an experimentally-validated predictive capability for magnetically confined fusion plasmas. Consisting of small-scale experiments primarily at universities, the EPR activity emphasizes plasma physics studies in a wide range of magnetic configurations. Recent investments have supported the operation of a variety of experimental facilities and a center providing theory and computational support to EPR experiments.

High Energy Density Laboratory Plasmas

High Energy Density (HED) physics is the study of ionized matter at extremely high density and temperature, specifically, matter that is heated and compressed to a point that the stored energy reaches approximately 100 billion Joules per cubic meter. Such extreme environments will be common in all future inertial fusion energy applications independent of the driver, and are also prominent in many astrophysical phenomena such as supernovae, relativistic jets, and planetary cores. The Matter at Extreme Conditions (MEC) end station of the Linac Coherent Light Source (LCLS) user facility at the SLAC National Accelerator Laboratory provides scientific users with access to HED regimes uniquely coupled with a high-brightness x-ray source, enabling experiments capable of addressing key questions in high energy density physics, laboratory astrophysics, laser-particle acceleration, and nonlinear optical science. In addition, the Office of Science (SC) works closely with the NNSA to steward a growing university community in HED science through the NNSA/FES Joint Program in high energy density laboratory plasma (HEDLP) science, and to leverage DOE-NNSA investments in defense facilities for broader scientific investigations.

Madison Symmetric Torus

The Madison Symmetric Torus (MST) experiment at the University of Wisconsin-Madison focuses on increasing the fundamental understanding of the physics of the reversed field pinch (RFP) magnetic configuration, expanding validated predictive capability of toroidal magnetic confinement, and advancing discovery science and its links to plasma astrophysics.

Theory

The Theory activity is focused on advancing the scientific understanding of the fundamental physical processes governing the behavior of magnetically confined plasmas. The efforts supported by this activity range from small single-investigator grants mainly at universities to large coordinated teams at national laboratories, universities, and private industry, while the supported research ranges from fundamental analytic theory to mid- and large-scale computational work using high-performance computing resources. In addition to its scientific discovery mission, the Theory activity provides the scientific grounding for the physics models implemented in the advanced simulation codes developed under the Scientific Discovery through Advanced Computing (SciDAC) activity and supports validation efforts at major experiments.

SciDAC

The FES Scientific Discovery Through Advanced Computing (SciDAC) activity, a component of the SC-wide SciDAC program, is aimed at advancing scientific discovery in fusion plasma science by exploiting leadership-class computing resources and associated advances in computational science. The FES SciDAC portfolio contributes to the FES goal of advancing the fundamental science of magnetically confined plasmas to develop the predictive capability required for a sustainable fusion energy source. The seven centers in the FES SciDAC portfolios address challenges in magnetic confinement science and computational fusion materials studies and are well-aligned with the needs of ITER. Two of these centers are set up as partnerships between FES and ASCR.

General Plasma Science

The General Plasma Science (GPS) activity addresses questions related to fundamental plasma properties and processes through discovery-based investigations in basic and low-temperature plasma science. Major components of the GPS activity include basic plasma science research at DOE national laboratories, low-temperature plasma science research through multi-institutional collaborations, small- to medium-scale plasma experimental platforms, and the NSF/DOE Partnership in Basic Plasma Science and Engineering, which supports exploratory single-investigator research at universities and industries.

Activities and Explanation of Changes ($K)

FY 2014 Enacted	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
DIII-D Research		
Research is conducted in three program areas, with DIII-D staff and collaborator support for diagnostics and data analysis to exploit the additional DIII-D operations in FY 2014:	Research will be conducted in the same three general program areas as in FY 2014:	The DIII-D research program is enhanced by increased collaboration of university researchers, exploiting expertise and knowledge developed in university research programs and allowing for increased student involvement on the DIII-D experiment.
▪ Dynamics and control studies to prepare for burning plasmas in ITER and develop viable steady-state options for fusion energy production.	▪ Dynamics and control studies to test transport models, evaluate plasma performance in ITER-like conditions, and begin exploring methods of active control to avoid disruptions and operate near stability boundaries under steady-state conditions.	
▪ Boundary and pedestal research to improve the understanding of Edge Localized Mode control and particle and energy transport in the edge plasma.	▪ Boundary and pedestal research to assess the benefits of divertor geometry in dissipating heat flux, investigate fueling and Edge Localized Mode control at higher density, and develop compatible core-edge solutions for high performance plasmas.	
▪ Burning plasma physics to advance the predictive capabilities to simulate future devices.	▪ Burning plasma physics research to explore and suppress energetic particle instabilities and to understand and control transport barrier formation and confinement transitions.	
Studies of 3D field effects utilize a new enhanced set of magnetic sensors. Disruption mitigation studies focus on providing a firm physics basis for the ITER disruption mitigation system.	Disruption studies will continue to be emphasized in order to guide the design of the ITER disruption mitigation system.	

FY 2014 Enacted	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Alcator C-Mod Research		
C-Mod research focuses on resolving high-priority issues of ITER-relevant boundary and divertor physics. Research areas include disruption mitigation studies, exploration of the I-mode operating regime, radio-frequency heating physics, and plasma edge/material interaction experiments.	C-Mod research will continue to focus on resolving high-priority issues of ITER-relevant boundary and divertor physics, with the goal of completing specific high priority research tasks relevant to ITER for which C-Mod is uniquely suited. Research areas will be similar to those for FY 2014. C-Mod scientists will initiate enhanced research collaborations on other experimental facilities.	C-Mod research staff will become increasingly involved in collaborative activities on other U.S. and international experiments as the C-Mod facility transitions to closure in late FY 2016.
International Research		
Two research teams continue their research collaborations on heating and control of long-pulse plasmas on EAST (China) and KSTAR (Korea). FES is supporting the work to fabricate and deliver the power supplies for the Wendelstein 7-X (W7-X) stellarator trim coils. FES also supports the effort to design and construct an x-ray imaging crystal spectrometer for the W7-X stellarator to measure the plasma temperature (electron and ion) and plasma flow velocity.	FES will continue to support the two teams working on EAST and KSTAR. FES will also support the work to complete the design of the scraper element for the W7-X steady-state divertor, a tool that will permit early experimental investigation of the edge magnetic configuration in the first full W7-X research campaign. One or two new university collaborations on international facilities may be initiated.	Scientific collaborations on a new generation of international fusion research facilities, including the EAST (China) and KSTAR (Korea) superconducting tokamaks and the Wendelstein 7-X (Germany) superconducting stellarator, will continue at a reduced level of effort.
Diagnostics		
The Diagnostics activity continues to develop innovative measurement techniques to address current and emerging needs in the FES research program.	Efforts will continue on developing innovative techniques to address current and emerging measurement needs in the FES program. A community-informed planning activity will be undertaken to assess the need for long pulse, plasma control, disruption, and burning plasma diagnostics.	Research on advanced diagnostics will continue at approximately the same level of effort.

FY 2014 Enacted	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Other		
Funding supports all the elements in this category, including the U.S. Burning Plasma Organization (USBPO) activities, HBCUs, peer reviews for solicitations, and FESAC. In addition, funding that supported increased computational and advanced measurement capabilities for validated fusion simulation development was placed in this category until decisions on its distribution could be implemented.	Funding will continue to support USBPO activities, HBCUs, peer reviews for solicitations, and FESAC.	Funding for many of the elements in this category will be eliminated, reduced, or absorbed by other parts of the FES program. The additional funding in FY 2014 for support of increased computational and advanced measurement capabilities for validated fusion simulation development is not continued in FY 2015. There is no funding for support of increased computational and advanced measurement capabilities for validated fusion simulation development.
NSTX Research		
The NSTX research staff complete development of advanced control algorithms for NSTX-U, and work on the design of the next generation of divertor plates, control coils, heating system upgrades, and diagnostics to be implemented during the following five-year research campaign.	The NSTX-U research staff will begin research on the enhanced facility. Initial experiments will concentrate on developing operating scenarios for high-performance plasmas, assessing transport and stability at higher plasma current and magnetic field, developing advanced divertor configurations, advancing techniques for non-inductive start-up, and assessing neutral-beam injection for current ramp-up and sustainment.	The increase in funding will support a significant expansion of the NSTX-U national research effort. The increase will restore the research team at PPPL to its pre-upgrade capability, fund increases in university and other national laboratory scientific teams, and increase the number of graduate students working on NSTX-U.
Experimental Plasma Research (EPR)		
EPR activities test the general validity of plasma physics and technology in a wider expanse of parameter regimes than those provided by current and future major magnetic confinement facilities.	Experiments will be designed to highlight and investigate individual physics principles of toroidal confinement and to validate theoretical models and simulation codes.	Research on experiments with emphasis on validation of theoretical models and simulation codes will be increased.

FY 2014 Enacted	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
High Energy Density Laboratory Plasmas (HEDLP)		
Fundamental HEDLP science is supported through academic grants as part of the SC/NNSA joint program in HEDLP science, research projects at DOE national laboratories, the establishment of a HEDLP physics research group at SLAC, and the operation of the MEC instrument at LCLS. Additionally, the program supports the advancement of heavy ion fusion science through the operation of the Neutralized Drift Compression Experiment –II (NDCX-II) at Lawrence Berkeley National Laboratory (LBNL).	Research utilizing the MEC instrument at LCLS will be emphasized, including: ▪ Continued support for the MEC beam-line science team and HEDLP research group at SLAC. ▪ Completion of phase two of the scheduled short-pulse laser upgrade to deliver 200 TW on target, and grants for external HED science users of MEC.	Contraction of the HEDLP program will result in no new academic grants for basic HEDLP research as part of the SC/NNSA joint program in HEDLP science, no new research projects in basic HEDLP science at DOE national laboratories, and the cessation of operations of the NDCX-II facility at LBNL.
Madison Symmetric Torus (MST)		
The MST activity focuses on reversed-field pinch (RFP) experiments and modeling efforts in support of toroidal research. Measurements of short-wavelength density and magnetic field fluctuations, and comparison with gyrokinetic calculations, will be made. Equilibrium reconstructions are developed for the three-dimensional helical state, and pressure-limiting mechanisms in the RFP will be assessed.	MST research will emphasize measurement of the scaling of tearing mode fluctuations with current and temperature to support the validation of nonlinear magnetohydrodynamic (MHD) codes. Physics extensions beyond MHD will be studied by measuring the Hall dynamo and comparing it to extended MHD simulations.	Diagnostic and modeling efforts will be increased.
Theory		
Continuing research activities at universities, national laboratories, and private industry are supported. For the selection of new and renewal awards via competitive merit reviews, priority is given to theoretical and computational research activities addressing issues of importance to ITER and burning plasmas.	The Theory activity will continue to support research efforts addressing high-priority issues for ITER and burning plasmas. Coordination between theory and experiment leading to model validation will be emphasized, especially in areas where the resolution of essential physics issues is urgently needed before first plasma in ITER.	Research activities on some issues will be reduced.

FY 2014 Enacted	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
SciDAC		
The research activities at most of the SciDAC centers in the FES portfolio are maintained at approximately the FY 2013 level of effort. In a few targeted areas, including the critical area of multiscale integrated modeling, the level of effort is increased.	The FES SciDAC centers continue to contribute to the FES goal of developing a predictive capability for fusion plasmas. The two FES-ASCR partnerships selected in FY 2012 will undergo a mid-term progress review. A new Funding Opportunity Announcement and companion notice to national laboratories will be issued to recompete the part of the portfolio represented by the five centers selected in FY 2011.	The FES SciDAC centers will maintain their research activities.
General Plasma Science		
Intermediate-scale facilities, the partnership with the National Science Foundation (NSF) in Basic Plasma Science and Engineering, and basic and applied plasma science research at DOE national laboratories are supported.	All core research elements of the General Plasma Science program will continue. With input from the NRC Plasma Science Committee, the program will also support: ▪ Multi-institutional teams targeting interdisciplinary connections. ▪ Intermediate-scale facilities expanding experimentally accessible parameters and providing broad access to users.	Research in General Plasma Science will continue at approximately the same level of effort.
SBIR/STTR		
SBIR/STTR funding is statutorily set at 3.2% of non-capital funding in FY 2014.	SBIR/STTR funding is statutorily set at 3.3% of non-capital funding in FY 2015.	No Change.

Fusion Energy Sciences
Facility Operations

Description

The Facility Operations subprogram support operation, maintenance, and modifications to the research equipment and diagnostics at the major U.S. fusion user facilities, carries out major upgrades to existing facilities, and constructs new facilities to advance toward a fusion energy source.

The current major experimental user facilities in the FES program—the NSTX spherical torus at the Princeton Plasma Physics Laboratory (PPPL) in Princeton, New Jersey, the DIII-D tokamak at General Atomics in San Diego, California, and the Alcator C-Mod tokamak at the Massachusetts Institute of Technology in Cambridge, Massachusetts—provide important tools for the U.S. and international research community to explore and resolve fundamental issues for fusion plasma science. They are operated as national scientific user facilities. The funding for these facilities provides modern experimental tools such as plasma heating, fueling, and exhaust systems and supports the operating time to conduct world-class innovative research.

The NSTX upgrade project will be completed early in FY 2015, and the facility will begin full research operations later in FY 2015 as NSTX-U.

The Alcator C-Mod facility resumed operation in FY 2014 and will continue operation at a reduced level in FY 2015 to complete student research and critical experimental work before the facility ceases operations at the end of FY 2016. FES will work with MIT to develop a plan for its scientists to transition to other research activities.

<u>DIII-D</u>

The DIII-D user facility is the largest magnetic fusion research experiment in the U.S. and can magnetically confine plasmas at temperatures relevant to burning plasma conditions. Researchers from the U.S. and abroad are able to perform experiments on DIII-D for studying stability, confinement, and other properties of fusion-grade plasmas under a wide variety of conditions.

<u>Alcator C-Mod</u>

The compact size and high magnetic field of the Alcator C-Mod tokamak make it useful for dimensionless scaling studies. It can operate at and above the ITER design values for magnetic field and plasma density, and it has all-metals walls that experience heat fluxes approaching those projected for ITER. Also, it produces tokamak plasmas with very high pressure, near that expected in a burning plasma.

<u>NSTX</u>

The NSTX user facility is an innovative fusion science facility at PPPL employing a spherical torus (ST) confinement configuration. A major advantage of this configuration is the ability to confine plasma at a pressure that is high compared to the magnetic field energy density, which could lead to the development of an efficient fusion nuclear science experiment based on the ST configuration.

The NSTX Upgrade Major Item of Equipment (MIE) project is currently underway. The new center stack assembly will enable a doubling of the magnetic field and plasma current and an increase in the plasma pulse length from 1 to 5 seconds, making NSTX the world's highest-performance ST. The addition of a second neutral beam system will double the heating power, making it possible to achieve higher plasma pressure and providing improved neutral beam current drive efficiency and current profile control, which is needed for achieving fully non-inductive operation. Together, these upgrades will support a strong research program to develop the improved understanding of the ST configuration required to establish the physics basis for next-step ST facilities, broaden scientific understanding of plasma confinement, and maintain U.S. world leadership in ST research. The capability for controllable fully-non-inductive current drive will also contribute to an assessment of the ST as a potentially cost-effective path to fusion energy. The total project cost (TPC) baseline of

$94,300,000 was approved at Critical Decision-2 (CD-2) in December 2010, and CD-3 approval to start fabrication was achieved in December 2011. Project completion is anticipated by early FY 2015.

Other, General Purpose Equipment (GPE), and General Plant Projects (GPP)

Funding in this category provides support for general infrastructure repairs and upgrades for the PPPL site. This funding is based upon quantitative analysis of safety requirements, equipment reliability, research needs, and environmental monitoring needs.

Activities and Explanation of Changes ($K)

FY 2014 Enacted	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
DIII-D		
The DIII-D user facility operates for 18 weeks to support experiments. Upgrades continue to the electron cyclotron auxiliary heating system, to achieve ITER-like equal ion and electron temperatures. Refurbishment of the Thomson scattering diagnostic improves the resolution and accuracy of electron density and temperature measurements, and repair of an internal magnetic perturbation coil for plasma stabilization returns the system to full capability to support research on 3-D field effects. Additional upgrades to power supply infrastructure are initiated to increase the experimental flexibility of the facility.	The DIII-D user facility will operate for 15 weeks to support experiments. An eighth gyrotron system will be operated for additional heating and current drive to expand the advanced tokamak and steady-state operating space of DIII-D. Upgrades to the power supply systems for the field shaping and magnetic perturbation coils will continue.	Run time will be reduced, with a decrease from 18 to 15 weeks, as resources are allocated to completing the upgrade tasks begun in FY 2014. Less funding for upgrade hardware is required, due to purchases made in FY 2014.
Alcator C-Mod		
The C-Mod facility operates for 12 weeks to support experiments and complete student research. Maintenance, refurbishment, and minor upgrades of tokamak systems and diagnostics are performed, with emphasis on tasks necessary for the safe and efficient operation of C-Mod. Upgrades funded by the American Recovery and Reinvestment Act (ARRA) continue to be deployed and used to support research.	The C-Mod facility will operate for 5 weeks to support experiments and complete student research. Maintenance and refurbishment activities to support the safe and efficient operation of C-Mod will continue	Run time will be reduced, and upgrade tasks will decrease.

FY 2014 Enacted	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
NSTX		
NSTX continues its shutdown as upgrade work continues. Installation of the new center stack assembly and the second neutral beamline are completed. Operations funding supports preparation of the systems not involved in the upgrade for resumption of operation in FY 2015.	With the completion of the MIE project, the operations team will complete integrated systems testing and begin research operations, with a goal of 18 weeks of operation. Funding is shifted from the MIE project back to facility operations. The design of facility modifications, including a divertor cryopump, a set of non-axisymmetric control coils, and a 1 MW electron cyclotron heating system, will be initiated.	Funding for the MIE project decreases with the completion of the project; however, overall funding for NSTX facility operations is increased to support resumption of research operations and the design and fabrication of additional diagnostic and facility modifications. Priority is given to operating time.
Other, General Purpose Equipment (GPE), and General Plant Projects (GPP)		
At PPPL, necessary facility and utility infrastructure improvements required to ensure mission readiness and enhance reliability will be accomplished. Several small projects will be executed to modernize and/or replace aging infrastructure elements such as electrical distribution and cooling water utilities and building heating, ventilation, and air conditioning systems. Environmental monitoring needs at PPPL are supported.	Support for non-research infrastructure at PPPL will continue in order to upgrade and replace existing systems. Environmental monitoring needs at PPPL will be supported.	In consideration of the proposed SC Science Laboratories Infrastructure project at PPPL, funding that supports non-research infrastructure at PPPL will be decreased.

Description

The Enabling R&D subprogram addresses scientific challenges by developing and continually improving the hardware, materials, and technology incorporated into existing and next-generation fusion research facilities, enabling these facilities to achieve higher levels of performance and flexibility and consequently allowing the exploration of new scientific regimes. In addition, this subprogram supports conceptual studies of future fusion systems to characterize critical research gaps.

The funding changes reflect the need to maintain efforts addressing significant long-term materials challenges as fusion moves into the burning plasma era and advances toward a viable energy source.

Plasma Technology

The Plasma Technology program develops tools to heat, fuel, and confine a burning plasma; breed and process the deuterium and tritium fuel; protect the interior surface of the plasma chamber from the harsh fusion environment; and assure that fusion facilities are operated in a safe and environmentally responsible manner. This program addresses potential ITER operational issues and frequently plays a significant role in international collaboration activities.

Advanced Design

Advanced Design funding provides support for conceptual studies of potential fusion systems. These studies help to identify the various scientific challenges to fusion energy and determine how to address them. In addition, this activity supports program planning activities.

Materials Research

The Materials Research program supports the development, characterization, and modeling of structural, plasma-facing, and blanket materials used in the fusion environment, which is extremely harsh in terms of temperature, particle flux, and irradiation. Materials that can withstand this environment under the long-pulse or steady-state conditions anticipated in future fusion experiments are a prerequisite to the future of fusion research and development activities.

Fusion Energy Sciences
Enabling R&D

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Plasma Technology		
Efforts continue to address the challenges and research gaps in this program element. A new U.S. Japan collaborative program focuses on materials characterization to evaluate improved tungsten alloys.	Increased emphasis will be placed on high-heat-flux devices and testing of materials samples under high heat conditions.	Support is decreased for all elements, including heating, fueling, and magnets.
Advanced Design		
Scoping studies are initiated to characterize significant research gaps and focus on fusion nuclear sciences programs required in order to build a fusion nuclear science facility.	Scoping studies will continue on characterizing significant research gaps in the materials and fusion nuclear sciences program required in order to build a fusion nuclear sciences facility.	The effort on scoping studies will be enhanced.
Materials Research		
Efforts increase in all activities. The focus is on the joining of Oxide Dispersion Strengthened steels and silicon carbide composites, fabrication of tungsten and corrosion resistant steels, liquid divertors and first wall technologies, and modeling/simulation of solid state and liquid materials.	Efforts will focus on elucidating the response of materials to the extreme conditions created by burning plasma. Key areas of interest will be fusion nuclear science and plasma-material interaction under reactor-relevant plasma conditions.	The experiments and modeling activity efforts focused on fusion nuclear science and plasma-material interaction will be decreased.

Description

The major international fusion project ITER, presently under construction in Cadarache, France, is designed to be the first magnetic confinement fusion facility to achieve self-heated (burning) plasmas. As ITER construction activities continue, careful and efficient management of the U.S. contributions to the international project by the U.S. ITER Project Office (USIPO) at Oak Ridge National Laboratory (ORNL) will be a high priority for FES.

ITER is designed to generate the world's first sustained (300 seconds, self-heated) burning plasma. It aims to generate fusion power 30 times the levels produced to date and to exceed the external power applied to the plasma by at least a factor of ten. ITER will be a powerful tool for discovery, capable of addressing the new challenges of the burning plasma frontier and assessing the scientific and technical feasibility of fusion energy.

The ITER Project is being designed and built by an international consortium consisting of the U.S., China, India, Japan, South Korea, the Russian Federation, and the European Union (the host). The U.S. is committed to the scientific mission of ITER and will work with ITER partners to accomplish this goal, while maintaining a balanced domestic research portfolio. Executing a fusion sciences program with well-aligned domestic and international components will sustain U.S. international leadership in fusion energy sciences. The U.S. magnetic fusion research program in experiment, theory, and computation is configured to make strong contributions to ITER's science and to bring a high level of scientific return from it. ITER joins the broader FES research portfolio in elevating plasma sciences for both practical benefit and increased understanding.

The U.S. Contributions to ITER Project activity is 9.09% of the ITER Project construction costs. The U.S. contributions, consisting of in-kind hardware components, personnel, and cash to the ITER Organization (IO) for the ITER construction phase, are established by the terms of the ITER Joint Implementation Agreement. In exchange for this contribution, the U.S. gains access to 100% of the ITER research output. ITER is similar to other modern large science projects being conducted as international collaborations that pool financial, technical, and scientific resources to achieve critical science at a scale beyond the reach of individual countries.

The U.S. contributions are managed by the USIPO, ORNL, in partnership with Princeton Plasma Physics Laboratory and Savannah River National Laboratory. The U.S. ITER Project differs from most other DOE and Office of Science (SC) projects in its in-kind hardware contribution obligations and in the risks associated with performing work that depends in large part on the execution of project responsibilities by our international partners. In the spring of 2012, in efforts to ensure a responsible budgetary approach while maintaining contributions to the project, DOE and its oversight organizations agreed to support an annual funding level of no more than $225,000,000 per year beginning in FY 2014. The present U.S. assessment of the project is that it cannot, under current conditions, meet the most recent schedule put forward by the IO. The requested level of funding for FY 2015 will ensure that U.S. in-kind contributions maintain U.S. commitment to FY 2015 project needs.

Activities and Explanation of Changes ($K)

FY 2014 Enacted	FY 2015 Request	FY 2015 vs FY 2014 Enacted
U.S. Contributions to ITER Project		
ITER contributions proceed in accordance with the two-year performance plan that was reviewed by the Office of Project Assessment and the Energy Systems Acquisition Advisory Board (ESAAB) and that was approved by the Acquisition Executive. The U.S. ITER Project Office is on track to deliver four shipments of toroidal field conductor to the European Union toroidal field magnet fabricator, drain tanks for tokamak cooling water, and hardware for the steady-state electrical network. In addition, the U.S. ITER Project Office starts fabrication of the first central solenoid module, completes various design reviews for the vacuum auxiliary system, and awards subcontracts for diagnostic design work.	Funding is provided for ITER Project Office operations; the U.S. cash contribution; and continued progress on in-kind contributions, including industrial procurements of central solenoid magnet modules and structures, toroidal field magnet conductor fabrication, diagnostics, and the tokamak cooling water system procurement.	Funding provided for critical path items will ensure that U.S. in-kind contributions maintain U.S. commitment to FY 2015 project needs.

Fusion Energy Sciences
Performance Measures

In accordance with the GPRA Modernization Act of 2010, the Department sets targets for, and tracks progress toward, achieving performance goals for each program. For more information, refer to the Department's FY 2013 Annual Performance Report. The following table shows the targets for FY 2013 through FY 2015.

	FY 2013	FY 2014	FY 2015
Performance Goal (Measure)	**FES Facility Based Experiments—Experiments conducted on major fusion facilities (DIII-D, Alcator C-Mod, NSTX) leading toward predictive capability for burning plasmas and configuration optimization**		
Target	Conduct experiments and analysis to explore enhanced confinement regimes without large edge instabilities, but with acceptable edge particle transport and a strong thermal transport barrier. Coordinated experiments, measurements, and analysis will be carried out to assess and understand the operational space for these conditions. Exploiting the complementary parameters and tools of the devices, joint teams will work to strengthen the basis for extrapolation of these regimes to ITER and other future fusion devices.	Conduct experiments and analysis to investigate and quantify plasma response to non-axisymmetric (3D) magnetic fields in tokamaks. Effects of 3D fields can be both beneficial and detrimental and research will aim to validate theoretical models in order to predict plasma performance with varying levels and types of externally imposed 3D fields. Dependence of response to multiple plasma parameters will be explored in order to gain confidence in predictive capability of the models.	Conduct experiments and analysis to quantify the impact of broadened current and pressure profiles on tokamak plasma confinement and stability. Broadened pressure profiles generally improve global stability but can also affect transport and confinement, while broadened current profiles can have both beneficial and adverse impacts on confinement and stability. This research will examine a variety of heating and current drive techniques in order to validate theoretical models of both the actuator performance and the transport and global stability response to varied heating and current drive deposition.
Result	Met	Not applicable	Not applicable
Endpoint Target	Magnetic fields are the principal means of confining the hot ionized gas of a plasma long enough to make practical fusion energy. The detailed shape of these magnetic containers leads to many variations in how the plasma pressure is sustained within the magnetic bottle and the degree of control that experimenters can exercise over the plasma stability. These factors, in turn, influence the functional and economic credibility of the eventual realization of a fusion power reactor. The key to their success is a detailed physics understanding of the confinement characteristics of the plasmas in these magnetic configurations. The major fusion facilities can produce plasmas that provide a wide range of magnetic fields, plasma currents, and plasma shapes. By using a variety of plasma control tools, appropriate materials, and having the diagnostics needed to measure critical physics parameters, scientists will be able to develop optimum scenarios for achieving high performance plasmas in ITER and, ultimately, in reactors.		

	FY 2013	FY 2014	FY 2015
Performance Goal (Measure)	**FES Facility Operations—Average achieved operation time of FES user facilities as a percentage of total scheduled annual operation time**		
Target	≥ 90%	≥ 90%	≥ 90%
Result	Met	Not applicable	Not applicable
Endpoint Target	Many of the research projects that are undertaken at the Office of Science's scientific user facilities take a great deal of time, money, and effort to prepare and regularly have a very short window of opportunity to run. If the facility is not operating as expected the experiment could be ruined or critically set back. In addition, taxpayers have invested millions or even hundreds of millions of dollars in these facilities. The greater the period of reliable operations, the greater the return on the taxpayers' investment.		
Performance Goal (Measure)	**FES Theory and Simulation—Performance of simulations with high physics fidelity codes to address and resolve critical challenges in the plasma science of magnetic confinement**		
Target	Carry out advanced simulations to address two of the most problematic consequences of major disruptions in tokamaks: the generation and subsequent loss of high-energy electrons (runaway electrons), which can damage the first wall, and the generation of large electromagnetic loads induced by disruptions, and assess the severity of these effects on ITER.	Understanding alpha particle confinement in ITER, the world's first burning plasma experiment, is a key priority for the fusion program. In FY 2014, determine linear instability trends and thresholds of energetic particle-driven shear Alfvén eigenmodes in ITER for a range of parameters and profiles using a set of complementary simulation models (gyrokinetic, hybrid, and gyrofluid). Carry out initial nonlinear simulations to assess the effects of the unstable modes on energetic particle transport.	Perform massively parallel plasma turbulence simulations to determine expected transport in ITER. Starting from best current estimates of ITER profiles, the turbulent transport of heat and particles driven by various microinstabilities (including electromagnetic dynamics) will be computed. Stabilization of turbulence by nonlinear self-generated flows is expected to improve ITER performance, and will be assessed with comprehensive electromagnetic gyrokinetic simulations.
Result	Met	Not applicable	Not applicable
Endpoint Target	Advanced simulations based on high-physics-fidelity models offer the promise of advancing scientific discovery in the plasma science of magnetic fusion by exploiting the Office of Science high-performance computing resources and associated advances in computational science. These simulations are able to address the multi-physics and multi-scale challenges of the burning plasma state and contribute to the FES goal of advancing the fundamental science of magnetically confined plasmas to develop the predictive capability needed for a sustainable fusion energy source.		

	FY 2013	FY 2014	FY 2015
Performance Goal (Measure)	**FES Construction/MIE Cost & Schedule—Cost-weighted mean percentage variance from established cost and schedule baselines for major construction, upgrade, or equipment procurement projects**		
Target	< 10%	< 10%	< 10%
Result	Met	Not applicable	Not applicable
Endpoint Target	Adhering to the cost and schedule baselines for a complex, large scale, science project is critical to meeting the scientific requirements for the project and for being good stewards of the taxpayers' investment in the project.		

Fusion Energy Sciences
Capital Summary ($K)

	Total	Prior Years	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Capital Operating Expenses Summary							
Capital equipment	n/a	n/a	146,773	24,371	24,371	8,739	-15,632
General plant projects (GPP)	n/a	n/a	45	5,400	5,400	2,500	-2,900
Total, Capital Operating Expenses	**n/a**	**n/a**	**146,818**	**29,771**	**29,771**	**11,239**	**-18,532**
Capital Equipment							
Major items of equipment							
ITER[a]	n/a	549,385	121,465	0	0	0	0
National Spherical Torus Experiment Upgrade (TPC $94,300)	83,665	33,695	22,800	23,700	23,700	3,470	-20,230
Total MIEs	**n/a**	**n/a**	**144,265**	**23,700**	**23,700**	**3,470**	**-20,230**
Other capital equipment projects under $2 million TEC	n/a	n/a	2,508	671	671	5,269	+4,598
Total, Capital equipment	**n/a**	**n/a**	**146,773**	**24,371**	**24,371**	**8,739**	**-15,632**
General Plant Projects							
General Plant Projects under $2 million TEC	n/a	n/a	45	5,400	5,400	2,500	-2,900

[a] Per Congressional direction, ITER became a line item in FY 2014

Major Items of Equipment Descriptions

National Spherical Torus Experiment Upgrade

This MIE project includes a new center stack to double the magnetic field and plasma current while increasing the plasma pulse length and a second neutral beam system to double the heating power, making NSTX the world's highest-performance spherical torus. Start of construction/execution (CD-3) was approved in December 2011. NSTX is shut down from FY 2012 through part of FY 2015 for the upgrade. The performance baseline for the MIE Project is $94,300,000 with completion in FY 2015.

Fusion Energy Sciences Funding Summary ($K)

	FY 2013 Current	FY 2014 Enacted	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Research	177,041	200,967	176,281	-24,686
Scientific user facility operations	52,410	74,610	83,124	+8,514
Major items of equipment	146,800	23,700	3,470	-20,230
Other (GPP, GPE, and infrastructure)	1,525	5,900	3,125	-2,775
Construction	0	199,500	150,000	-49,500
Total, Fusion Energy Sciences	**377,776**	**504,677**	**416,000**	**-88,677**

Scientific User Facility Operations and Research ($K)

	FY 2013 Current	FY 2014 Enacted	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
DIII-D National Fusion Facility	$64,078	$74,958	$69,423	-$5,535
Achieved operating hours	528	N/A	N/A	
Planned operating hours	480	720	600	-120
Optimal hours	1,000	1,000	1,000	0
Percent of optimal hours	52.8%	72%	60%	
Unscheduled downtime hours	16	N/A	N/A	
Number of users	230	270	275	+5
Alcator C-Mod	$16,677	$21,940	$18,000	-$3,940
Achieved operating hours	0	N/A	N/A	
Planned operating hours	0	384	160	-224
Optimal hours	0	800	800	0
Percent of optimal hours	0%	48%	20%	
Unscheduled downtime hours	0	N/A	N/A	

	FY 2013 Current	FY 2014 Enacted	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Number of users	100	90	75	-15
National Spherical Torus Experiment	$30,609	$38,656	$59,884	+$21,228
Achieved operating hours	0	N/A	N/A	
Planned operating hours	0	0	720	+720
Optimal hours	0	0	1,000	+1000
Percent of optimal hours	0	N/A	72%	
Unscheduled downtime hours	0	N/A	N/A	
Number of users	0	165	250	+85
Total, Facilities users and hours	$111,364	$135,554	$147,307	+$11,753
Achieved operating hours	528	N/A	N/A	
Planned operating hours	480	1,104	1,480	+376
Optimal hours	1,000	1,800	2,800	+1000
Percent of optimal hours (funding weighted)	52.8%	61.3%	52.9%	
Unscheduled downtime hours	16	N/A	N/A	
Number of Users	330	525	600	+75

Scientific Employment

	FY 2013 Actual	FY 2014 Estimate	FY 2015 Estimate	FY 2015 vs. FY 2014
Number of laboratory projects	168	169	139	-30
Number of permanent Ph.D.'s (FTEs)	697	710	622	-88
Number of postdoctoral associates (FTEs)	94	91	66	-25
Number of graduate students (FTEs)	276	264	208	-56
Number of Ph.D.'s awarded	44	42	34	-8

14-SC-60, U.S. Contributions to ITER

1. Summary and Significant Changes

The U.S. Contributions to ITER project described in this Project Data Sheet (PDS) is a U.S. Department of Energy project to provide the U.S. share of ITER hardware and cash contributions to support ITER construction. ITER is a major fusion research facility being constructed in France by an international partnership of seven governments. Since it does not result in a facility owned by or located in the U.S., it is not a capital asset project in the typical sense. Sections of this report have also been tailored accordingly to reflect the nature of this project. This PDS does not constitute a new start.

The U.S. Contributions to ITER is managed as a DOE Office of Science (SC) project. The project began as a major item of equipment (MIE) project in FY 2006 and changed to a Congressional control point beginning in FY 2014. This does not change SC's overall management approach for the U.S. ITER Project. As with all SC projects, the principles encoded in DOE Order 413.3B will be applied including critical decision milestones and their supporting prerequisite activities. Requirements for project documentation, monitoring and reporting, change control, and regular independent peer reviews will be applied with the same degree of rigor.

The most recent DOE O 413.3B approved Critical Decision (CD) is CD-1, Approve Alternative Selection and Cost Range, which was signed on January 25, 2008. Critical Decision 0 (CD-0) was approved in 2005 with a preliminary cost range of $1.45–$2.2 billion and projected completion date in FY 2014. Since CD-1, it has not been possible to baseline the project due to both technical challenges and continued delays in the international ITER construction schedule. Until such time as CD-2 can be approved, the U.S. contributions will be managed to address annual project needs and allow flexibility to adapt to the changing state of the project. Since the Project does not have CD-2 approval, the schedule and cost estimates contained in this PDS are TBD.

The approving official for CD-2 is the Director of the Office of Science (SC-1).

As of December 2013, design of the hardware to be supplied by the U.S. is 51% complete, with the two largest U.S. hardware contributions (by value) nearing completion of final design.

2. Critical Decision (CD) Schedule

	CD-0	CD-1	CD-2	CD-3	CD-4
FY 2006	7/5/2005	TBD	TBD	TBD	TBD
FY 2007	7/5/2005	TBD	TBD	TBD	TBD
FY 2008	7/5/2005	1/25/2008	4Q FY 2008	TBD	TBD
FY 2009	7/5/2005	1/25/2008	4Q FY 2010	TBD	TBD
FY 2010	7/5/2005	1/25/2008	4Q FY 2011	TBD	TBD
FY 2011	7/5/2005	1/25/2008	4Q FY 2011	TBD	TBD
FY 2012	7/5/2005	1/25/2008	3Q FY 2012	TBD	TBD
FY 2013	7/5/2005	1/25/2008	TBD[a]	TBD	TBD
FY 2014	7/5/2005	1/25/2008	TBD	TBD	TBD
FY 2015[b]	7/5/2005	1/25/2008	TBD	TBD	TBD

[a] The CD-2 date will be determined upon acceptable resolution of issues related to development of a high-confidence ITER Project Schedule and other international project uncertainties.
[b] This project is pre-CD-2, and the schedule and cost estimate are preliminary.

CD-0 – Approve Mission Need
CD-1 – Approve Alternative Selection, Cost Range, and Start of Long-lead Procurements
CD-2 – Approve Performance Baseline
CD-3 – Approve Start of Fabrication
CD-4 – Approve Project Completion

3. Baseline and Validation Status

Since CD-1, it has not been possible to baseline the project due to both technical challenges and continued delays in the international ITER construction schedule. The factors that delayed CD-2 approval (e.g., schedule delays, design and scope changes, regulatory requirements, risk mitigations, and project management issues in the ITER Organization) have placed upward pressure on the cost range. The current best estimate of the total cost range, prior to CD-2, is $4,000,000,000-$6,500,000,000.

4. Project Description, Scope, and Justification

Introduction

ITER is an international partnership among seven Member governments (China, the European Union, India, Japan, the Republic of Korea, the Russian Federation, and the United States) aimed at demonstrating the scientific and technological feasibility of fusion energy for peaceful purposes. The *Agreement on the Establishment of the ITER International Fusion Energy Organization for the Joint Implementation of the ITER Project* (ITER Agreement), signed on November 21, 2006 provides the legal framework for the four phases of the program: construction, operation, deactivation, and decommissioning. The ITER Agreement specifies that, as the Host, the European Union will bear five-elevenths (45.45%) of the ITER facility's construction cost, while the other six Members, including the U.S., will each support one-eleventh (9.09%) of the total cost. The ITER Agreement also provides for operation, deactivation, and decommissioning of the facility to be funded through a different cost-sharing formula in which the U.S. will contribute a 13% share. Responsibility for ITER integration, management, design, licensing, installation, and operation rests with the ITER Organization (IO), which is an international legal entity located in France.

Mission Need

The February 2005 CD-0 document entitled "Mission Need Statement for a Fusion Facility for Sustained Burning Plasma Research" states the mission need and the analysis to support the mission need. The need is based on the mission of the Office of Fusion Energy Sciences to lead the national research effort to advance plasma science, fusion science, and fusion technology. From the 2005 CD-0 statement:

> There is a distinct need to investigate the fusion process in the performance region between the current scientific knowledge base and that needed for a practical fusion power. There are two parts of this need. The first part is to investigate the fusion process in the form of a "burning plasma," in which the heat generated by the fusion process exceeds that supplied from external sources by a significant amount (e.g., with a "gain factor" of at least ten). Some of this heat is used to help sustain the burning plasma while fresh fuel is being added, but the majority of this heat is captured in a blanket and used to make power available for producing electricity. The second part of this need is to sustain the burning plasma for a long duration, (e.g., several hundred to a few thousand seconds, during which time equilibrium conditions can be achieved within the plasma and adjacent structures). In the major fusion programs around the world, no fusion research facility exists or is being built in which such sustained burning plasmas can be achieved. The existing facilities have reached their limits, where the heat generated in the plasma is about equal to that supplied to the plasma from external sources, a gain of about unity. At this level of performance, the plasma behavior is dominated by external heating rather than self-heating. The duration of such experiments is only on the order of 10 seconds.

> Today, fusion research is at the threshold of exploring sustained burning plasma in which self-heating dominates the plasma behavior. Such exploration is a necessary step toward the realization of a fusion energy source; it must be done to establish the confidence in proceeding with development of a demonstration fusion power plant.
>
> Accordingly, the mission need is to establish a fusion facility for sustained burning plasma research.

There have been no material changes to the U.S. ITER Project Mission Need Statement since it was approved. The overall ITER project mission remains the same: to internationally construct a research facility that will demonstrate the scientific and technological feasibility of fusion energy.

<u>ITER Construction Project Scope</u>

The scope of U.S. Contributions to ITER represents 9.09% of the total international ITER construction.The U.S. ITER project includes three major elements:

- Hardware components, built under the responsibility of the U.S., then shipped to the ITER site for IO assembly, installation, and operation.
- Cash to the IO to support common expenses, including ITER research and development (R&D), IO staff and infrastructure, IO-provided hardware, on-site assembly/installation/testing of all ITER components, and IO Central Reserve, which serves as a contingency fund.
- Other costs, including R&D and conceptual design related activities.

The U.S. ITER project hardware scope is limited to design, fabrication, and delivery of mission-critical tokamak subsystems and is described below.

- **Tokamak Cooling Water System**: manages power generated during the operation of the tokamak.
- **15% of ITER Diagnostics**: provide the measurements necessary to control, evaluate, and optimize plasma performance and to further the understanding of plasma physics.
- **Disruption Mitigation Systems**: limit the impact of plasma disruptions to the tokamak vacuum vessel, blankets, and other components.
- **Electron Cyclotron Heating Transmission Lines**: bring additional power to the plasma and deposits power in specific areas of the plasma to minimize instabilities and optimize performance.
- **Tokamak Exhaust Processing System**: separates hydrogen isotopes from tokamak exhaust.
- **Fueling System (Pellet Injection)**: injects fusion fuels in the form of deuterium-tritium ice pellets into the vacuum chamber.
- **Ion Cyclotron Heating Transmission Lines**: bring additional power to the plasma.
- **Central Solenoid Magnet System**: confines, shapes and controls the plasma inside the vacuum vessel.
- **8% of Toroidal Field (TF) Conductor**: component of the TF magnet that confines, shapes, and controls the plasma.
- **75% of the Steady State Electrical Network**: supplies the electricity needed to operate the entire plant, including offices and the operational facilities.
- **Vacuum Auxiliary System**: creates low gas pressures in the vacuum vessel and connected vacuum components.
- **Roughing Pumps**: evacuate the tokamak, cryostat, and auxiliary vacuum chambers prior to and during operations.

5. Financial Schedule

(dollars in thousands)

	Appropriations	Obligations	Costs
Total Estimated Cost (TEC)			
Hardware			
FY 2006	13,754	13,754	6,169
FY 2007	34,588	34,588	24,238
FY 2008	25,500	25,500	24,122
FY 2009	85,401	85,401	26,278
FY 2010	85,266	85,266	46,052
FY 2011	63,875	63,875	84,321
FY 2012	91,716	91,716	99,264
FY 2013	107,694	107,694	110,358
FY 2014[a]	159,458	159,458	201,533
FY 2015	102,726	102,726	130,980
Subtotal	769,978	769,978	753,315
FY 2016–	TBD	TBD	TBD
Total, Hardware	TBD	TBD	TBD
Cash contributions			
FY 2006	2,112	2,112	2,112
FY 2007	7,412	7,412	7,412
FY 2008	2,644	2,644	2,644
FY 2009	23,599	23,599	23,599
FY 2010	29,734	29,734	29,734
FY 2011	3,125	3,125	3,125
FY 2012	13,214	13,214	13,214
FY 2013	13,805	13,805	13,805
FY 2014[a]	35,042	35,042	35,042
FY 2015	41,913	41,913	41,913
Subtotal	172,600	172,600	172,600
FY 2016–	TBD	TBD	TBD
Total, Cash Contributions	TBD	TBD	TBD
Total, TEC	TBD	TBD	TBD

[a] Appropriations prior to FY 2014 reflect major item of equipment funding. Starting in FY 2014, this project is funded as a Congressional control point.

(dollars in thousands)

	Appropriations	Obligations	Costs
Other project costs (OPC)			
FY 2006	3,449	3,449	1,110
FY 2007	18,000	18,000	7,607
FY 2008	-2,074	-2,074	7,513
FY 2009	15,000	15,000	5,072
FY 2010	20,000	20,000	7,754
FY 2011	13,000	13,000	10,032
FY 2012	70	70	22,322
FY 2013	2,535	2,535	5,760
FY 2014	5,000	5,000	7,281
FY 2015	5,361	5,361	5,316
Subtotal	80,341	80,341	79,767
FY 2016–	TBD	TBD	TBD
Total, OPC	TBD	TBD	TBD
Total Project Costs (TPC)			
FY 2006	19,315	19,315	9,391
FY 2007	60,000	60,000	39,257
FY 2008	26,070	26,070	34,279
FY 2009	124,000	124,000	54,949
FY 2010	135,000	135,000	83,540
FY 2011	80,000	80,000	97,478
FY 2012	105,000	105,000	134,800
FY 2013	124,034	124,034	129,923
FY 2014[a]	199,500	199,500	243,856
FY 2015	150,000	150,000	178,209
Subtotal	1,022,919	1,022,919	1,005,682
FY 2016–	TBD	TBD	TBD
Total, TPC	TBD	TBD	TBD

6. Details of the 2014 Project Cost Estimate

The current best estimate of the total cost range, prior to CD-2, is $4,000,000,000-$6,500,000,000. This range was determined under the assumption that the annual funding level will not exceed $225,000,000 per year through first plasma;

[a] Appropriations prior to FY 2014 reflect major item of equipment funding. Starting in FY 2014, this project is funded as a Congressional control point.

and taking into account risks associated with assembly and operations costs, the international project schedule, nuclear construction, and technical challenges in providing U.S. project hardware scope.

7. Schedule of Appropriation Requests

(dollars in thousands)

Request Year		Prior Years	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	Outyears	Total
FY 2006	TEC	738,000	151,000	120,000	29,000	0	0	0	1,038,000
	OPC	65,100	9,300	6,200	3,400	0	0	0	84,000
	TPC	803,100	160,300	126,200	32,400	0	0	0	1,122,000
FY 2007	TEC	619,366	180,785	130,000	116,900	30,000	0	0	1,077,051
	OPC	44,449	500	0	0	0	0	0	44,949
	TPC	663,815	181,285	130,000	116,900	30,000	0	0	1,122,000
FY 2008	TEC	619,366	181,964	130,000	116,900	30,000	0	0	1,078,230
	OPC	43,770	0	0	0	0	0	0	43,770
	TPC	663,136	181,964	130,000	116,900	30,000	0	0	1,122,000
FY 2009[a]	TEC	266,366	TBD	TBD	TBD	TBD	TBD	TBD	TBD
	OPC	38,075	TBD	TBD	TBD	TBD	TBD	TBD	TBD
	TPC	304,441	TBD	TBD	TBD	TBD	TBD	TBD	TBD
FY 2010	TEC	294,366	TBD	TBD	TBD	TBD	TBD	TBD	TBD
	OPC	70,019	TBD	TBD	TBD	TBD	TBD	TBD	TBD
	TPC	364,385	TBD	TBD	TBD	TBD	TBD	TBD	TBD
FY 2011	TEC	304,366	75,000	TBD	TBD	TBD	TBD	TBD	TBD
	OPC	60,019	5,000	TBD	TBD	TBD	TBD	TBD	TBD
	TPC	364,385	80,000	TBD	TBD	TBD	TBD	TBD	TBD
FY 2012[b]	TEC	304,366	TBD	90,000	TBD	TBD	TBD	TBD	TBD
	OPC	60,019	TBD	15,000	TBD	TBD	TBD	TBD	TBD
	TPC	364,385	TBD	105,000	TBD	TBD	TBD	TBD	TBD
FY 2013	TEC	304,366	67,000	104,930	140,965	TBD	TBD	TBD	TBD
	OPC	60,019	13,000	70	9,035	TBD	TBD	TBD	TBD
	TPC	364,385	80,000	105,000	150,000	TBD	TBD	TBD	TBD

[a] The Prior Years column for FY 2009 through FY 2012 reflects the total of appropriations and funding requests only through the year of that row. Thus, for example, in the FY 2010 row, it reflects only funding from FY 2006 to FY 2010.
[b] The FY 2012 request was submitted before a full-year appropriation for FY 2011 was in place, and so FY 2011 was TBD at that time. Hence, the Prior Years column for FY 2012 reflects appropriations for FY 2006 through FY 2010 plus the FY 2012 request.

Request Year		Prior Years	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	Outyears	Total
		(dollars in thousands)							
FY 2014	TEC	304,366	67,000	104,930	105,572	225,000	TBD	TBD	TBD
	OPC	60,019	13,000	70	70	0	TBD	TBD	TBD
	TPC	364,385	80,000	105,000	105,642[a]	225,000	TBD	TBD	TBD
FY 2015[b]	TEC	310,010	67,000	104,930	121,499	194,500	144,639	TBD	TBD
	OPC	54,375	13,000	70	2,535	5,000	5,361	TBD	TBD
	TPC	364,385	80,000	105,000	124,034	199,500	150,000	TBD	TBD

8. Related Operations and Maintenance Funding Requirements

The U.S. Contributions to ITER operations is assumed to begin with initial commissioning activities and continue for a period of 15 to 25 years. The fiscal year in which commissioning activities begin depends on the international ITER project schedule and is therefore TBD.

Start of Operation or Beneficial Occupancy (fiscal quarter or date)	TBD
Expected Useful Life (number of years)	15–25
Expected Future start of D&D for new construction (fiscal quarter)	TBD

9. D&D Funding Requirements

Since ITER is being constructed in France by a coalition of countries and will not be a DOE asset, the “one-for-one” requirement is not applicable to this project.

The U.S. Contributions to ITER Decommissioning are assumed to begin when operations commence and continue for a period of 20 years. The U.S. is responsible for 13 percent of the total decommissioning cost.

The U.S. Contributions to ITER Deactivation are assumed to begin 20 years after commissioning and continue for a period of 5 years. The U.S. is responsible for 13 percent of the total deactivation cost.

10. Acquisition Approach for US Hardware Contributions

The USIPO, with its two partner laboratories, will procure and deliver in-kind hardware in accordance with the Procurement Arrangements established with the IO.

The USIPO will subcontract with a variety of research and industry sources for design and fabrication of its ITER components, ensuring that designs are developed that permit fabrication, to the maximum extent possible, under fixed-price subcontracts (or fixed-price arrangement documents with the IO) based on performance specifications, or more rarely, on build-to-print designs. USIPO will use cost-reimbursement type subcontracts only when the work scope precludes accurate and reasonable cost contingencies being gauged and established beforehand.

USIPO will utilize best value, competitive source selection procedures to the maximum extent possible, including foreign firms on the tender/bid list where appropriate. Such procedures shall allow for cost and technical trade-offs during source selection.

For the large-dollar-value subcontracts (and critical path subcontracts as appropriate), USIPO will utilize unique subcontract provisions to incentivize cost control and schedule performance.

[a] The FY 2013 amount shown in the FY 2014 request reflected a short-term continuing resolution level annualized to a full year and based on the FY 2012 funding level for ITER.
[b] Prior to FY 2015, the requests were for a major item of equipment broken out by TEC, OPC, and TPC.

In addition, where it is cost effective and it reduces risk, the USIPO will participate in common procurements led by the IO, or request the IO to perform activities that are the responsibility of the U.S.

High Energy Physics

Overview

The High Energy Physics (HEP) program mission is to understand how the universe works at its most fundamental level by discovering the elementary constituents of matter and energy, probing the interactions between them, and exploring the basic nature of space and time.

HEP offers research opportunities for individual investigators and small-scale collaborations, as well as very large international collaborations, chosen for their scientific merit and potential for significant impact. More than 20 HEP-supported physicists have received the Nobel Prize. Moreover, many of the advanced technologies and research tools originally developed for high energy physics have proven widely applicable to other sciences as well as industry, medicine, and national security.

Our current understanding of the elementary constituents of matter and energy is captured in what is called the Standard Model of particle physics. It is incredibly successful, yet known to be incomplete. It describes the elementary particles comprising ordinary matter, and forces that govern them, with very high precision. Astronomical observations indicate, however, that ordinary matter makes up only about 5% of the universe, the remainder being 70% dark energy and 25% dark matter, both “dark” because they are either nonluminous or unknown. Neither is described by the Standard Model. The observation of very small but non-zero masses of the elementary particles known as neutrinos provides further hints of new physics beyond the Standard Model.

A world-wide program of particle physics research is underway to discover what lies beyond the Standard Model. HEP supports a research program that can be described by three scientific frontiers:

- *The Energy Frontier,* using the highest energy accelerators available to create particles never before seen in the laboratory, revealing their interactions, and investigating fundamental forces using the highest energy accelerators available;
- *The Intensity Frontier,* using intense particle beams, massive detectors, and/or high precision detectors to investigate fundamental forces and particle interactions by studying events that occur rarely in nature; and
- *The Cosmic Frontier,* using advanced telescopes and underground detectors to measure astrophysical phenomena that offer new insight and information about the nature of dark matter and dark energy and about fundamental forces and particle properties.

Together, these complementary discovery frontiers, along with critical supporting thrusts in advanced accelerator and detector technologies, and theory and computation, offer the opportunity to answer some of the most basic questions about the world around us, including:

- How does mass originate?
- Why is the world made of matter and not anti-matter?
- What is dark energy? Dark matter?
- What are the origins of the universe? Can particle physics explain earliest moments of the universe when the four fundamental forces were still unified?

The experimental subprograms are supported by the Theoretical and Computational Physics and the Advanced Technology R&D subprograms. Theoretical and Computational Physics provides the theoretical models needed to explain the experimental data as well as predictions for experimental tests. That subprogram also provides simulations and data analysis tools. The Advanced Technology R&D subprogram supports the development of new accelerator and detector technologies to extend the capabilities of the experimental physics programs.

The Accelerator Stewardship subprogram is unique in the High Energy Physics program in that its mission is to explicitly support long–term research and development with application beyond the HEP program, including the needs of the rest of the Office of Science, other government agencies, and industry.

Highlights of the FY 2015 Budget Request

DOE and the National Science Foundation (NSF) have charged the High Energy Physics Advisory Panel with developing an updated strategic plan for the field of U.S. high energy physics that can be executed over a ten-year timescale. This report is expected in May 2014. The FY 2015 budget request supports full operation of existing HEP facilities and experiments; the planned construction funding profile for the Muon to Electron Conversion Experiment (Mu2e); and initiate fabrication for new major items of equipment (MIEs) for the LHC ATLAS (A Large Toroidal LHC Apparatus) Detector Upgrade and the LHC Compact Muon Solenoid (CMS) Detector Upgrade. Capital equipment funding is requested to support the planned funding profiles for the camera for the Large Synoptic Survey Telescope (LSST), the Muon g-2 Experiment, and a U.S. contribution to the upgrade of the Belle detector at the Super B-Factory in Japan (Belle II).

Energy Frontier Experimental Physics

Operations of the Large Hadron Collider (LHC) at CERN will resume in 2015 at energies of at least 13 TeV, a substantial increase from 8 TeV in the last run. This will increase the reach of the LHC to the search for new physics, particularly in high-impact topics such as supersymmetry, dark matter candidates, and evidence for extra space-time dimensions. Investments for U.S. contributions to future planned LHC detector upgrades that will exploit the full physics potential of the higher luminosities.

Intensity Frontier Experimental Physics

FY 2015 will feature the first full year of operations for the NOvA detector in the world's most intense neutrino beam. The physics goals of this experiment include improved measurements of neutrino mixing and first results on the neutrino mass hierarchy and the search for CP violation in the neutrino sector.

The Mu2e construction project and the Muon g-2 major item of equipment will be in the fabrication phase. These experiments will probe energy scales beyond the LHC through the study of rare processes and precision measurements. U.S. contributions to the Belle II will be complete in FY 2015. The Belle II detector is located at the Japanese B-factory and will study rare decays and CP violation in the heavy quark systems.

Cosmic Frontier Experimental Physics

The Dark Energy Survey continues operations in FY 2015, leading to the next-generation experiment. The LSST camera MIE in its second year of fabrication. The experiments performing direct searches for dark-matter particles will be in transition, as a large suite of first-generation experiments are planned to complete operations by FY 2015. In FY 2015, HEP will fund the research needed to develop a second generation of dark matter experiments and respond to recommendations of the community planning effort to be completed in FY 2014.

Theoretical and Computational Physics

The current high priority thrusts of the Theoretical Physics subprogram are to understand the LHC data and develop new search strategies that can be used at the LHC in the future; developing new models of dark matter; and other topics.

The computational physics effort supports research on computation, simulation, data tools, and software that cut across all HEP programs. An extension of the Lattice Quantum Chromodynamics (LQCD) project is planned in FY 2015. The LQCD IT Project is jointly funded by HEP and NP to provide optimized and dedicated computer hardware to simulate the fundamental interactions of quarks and gluons via the strong interaction that underlies many of the physics processes studied in both programs. Coordination with NP on LQCD ensures that the research results are productively used by both communities and avoids the potential for duplicative efforts.

Advanced Technology R&D

HEP built the FACET (Facility for Advanced Accelerator Experimental Tests at SLAC) and BELLA (Berkeley Lab Laser Accelerator at LBNL) facilities to support research on using plasmas to accelerate charged particles more effectively. Both have begun successful operation, reported first results, and are supported in the FY 2015 budget request. This technique has the promise of reducing the size of particle accelerators by 90–99%, making them less expensive. The energy to drive the plasma can come either from lasers (BELLA) or electron beams (FACET). As of the summer of 2013 both techniques have successfully accelerated beams without degrading their structure. These discoveries will be followed with comprehensive research programs to determine if practical particle accelerators can be built with these techniques.

The LHC Accelerator Research Program (LARP) focuses on research for the construction of the powerful focusing magnets made from niobium-tin superconductor which have higher magnetic fields than magnets currently in the LHC. Successful development of these magnets will allow the U.S. to make a unique and critical contribution to the upgrade of the LHC to produce more particle collisions per second, which will provide more data for the experimenters. Funding for this effort is increased in FY 2015.

Accelerator Stewardship

The Accelerator Stewardship subprogram supports long-term multi-purpose accelerator research applicable to fields beyond HEP. This includes extensions of the accelerator science research conducted under the HEP General Accelerator R&D portfolio, which is broadly applicable to other fields of science and seeks to identify and support R&D in specific technological areas important to a variety of accelerator applications, such as high-power lasers. In FY 2015, funding is increased to support new research activities for selected technology areas such as laser, ion-beam therapy, and green RF sources, with priorities informed by workshops held by HEP.

Construction

Two construction projects are underway to support Intensity Frontier Physics. The Muon to Electron Conversion Experiment (Mu2e), which will search for violation of charged lepton conservation, will complete its design phase in FY 2015 and move into full construction. The Long Baseline Neutrino Experiment continues its design phase.

High Energy Physics
Funding ($K)

	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Energy Frontier Experimental Physics					
Research	89,172	96,129	96,129	81,132	-14,997
Facility Operations and Experimental Support	60,274	58,558	58,558	57,507	-1,051
Projects	0	0	0	15,000	+15,000
Total, Energy Frontier Experimental Physics	**149,446**	**154,687**	**154,687**	**153,639**	**-1,048**
Intensity Frontier Experimental Physics					
Research	52,860	52,562	52,562	51,459	-1,103
Facility Operations and Experimental Support	158,058	185,481	185,481	174,816	-10,665
Projects	63,494	37,000	37,000	24,970	-12,030
Total, Intensity Frontier Experimental Physics	**274,412**	**275,043**	**275,043**	**251,245**	**-23,798**
Cosmic Frontier Experimental Physics					
Research	48,652	62,364	62,364	48,553	-13,811
Facility Operations and Experimental Support	12,252	12,022	12,022	11,692	-330
Projects	19,159	24,694	24,694	41,000	+16,306
Total, Cosmic Frontier Experimental Physics	**80,063**	**99,080**	**99,080**	**101,245**	**+2,165**
Theoretical and Computational Physics					
Research					
Theory	54,621	51,196	51,196	49,630	-1,566
Computational HEP	8,577	8,474	8,474	8,220	-254
Total, Research	63,198	59,670	59,670	57,850	-1,820
Projects	3,200	3,200	3,200	1,000	-2,200
Total, Theoretical and Computational Physics	**66,398**	**62,870**	**62,870**	**58,850**	**-4,020**
Advanced Technology R&D					
Research					
HEP General Accelerator R&D	60,705	57,694	57,694	47,620	-10,074
HEP Directed Accelerator R&D	22,692	23,500	23,500	26,000	+2,500
Detector R&D	27,405	23,947	23,947	23,229	-718
Total, Research	110,802	105,141	105,141	96,849	-8,292

	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Facility Operations and Experimental Support	31,489	17,150	17,150	17,393	+243
Total, Advanced Technology R&D	**142,291**	**122,291**	**122,291**	**114,242**	**-8,049**
Accelerator Stewardship					
Research	82	6,581	6,581	16,384	+9,803
Facility Operations and Experimental Support	3,050	3,350	3,350	2,800	-550
Total, Accelerator Stewardship	**3,132**	**9,931**	**9,931**	**19,184**	**+9,253**
SBIR/STTR	0	21,619	21,619	20,595	-1,024
Subtotal, High Energy Physics	**715,742**	**745,521**	**745,521**	**719,000**	**-26,521**
Construction					
Long Baseline Neutrino Experiment	3,781	16,000	16,000	0	-16,000
Muon to Electron Conversion Experiment	8,000	35,000	35,000	25,000	-10,000
Total, Construction	**11,781**	**51,000**	**51,000**	**25,000**	**-26,000**
Total, High Energy Physics	**727,523**	**796,521**	**796,521**	**744,000**	**-52,521**

SBIR/STTR:

- FY 2013 transferred: SBIR: $18,405,000; STTR: $2,386,000
- FY 2014 projected: SBIR: $18,916,000; STTR: $2,703,000
- FY 2015 Request: SBIR: $18,098,000; STTR: $2,497,000

High Energy Physics
Explanation of Major Changes ($K)

	FY 2015 vs. FY 2014 Enacted
Energy Frontier Experimental Physics: Reductions in research funding are due to the completion of the Tevatron research program, and overall programmatic reductions in research activities to support current and future experimental capabilities. This is offset by an increase in funding for initial LHC detector upgrade activities, scheduled for completion by 2018.	-1,048
Intensity Frontier Experimental Physics: Reductions are dominated by the ramp-down of funding associated with current projects (particularly NOvA). Funding for the SLAC B-factory operations is eliminated as planned disassembly work is completed. This is partially offset by increases in funding for initial operations of the upgraded NuMI beamline for NOvA, refurbishment of the oldest portions of the Fermilab accelerator complex, and support for R&D and fabrication of current and future experiments.	-23,798
Cosmic Frontier Experimental Physics: Funding increases are dominated by the ramp-up of the LSSTcam MIE according to its planned profile. Funding for research activities decreases and is redirected to R&D and planning efforts for the next generation of dark matter and dark energy experiments.	+2,165
Theoretical and Computational Physics: Funding for theoretical and computational HEP research is reduced to offset increased investments in future facilities.	-4,020
Advanced Technology R&D: Research activities are reduced to offset increased project funding, as well as a shift towards more directed R&D activities to develop future experimental capabilities.	-8,049
Accelerator Stewardship: This subprogram focuses on the fundamental physics of charged particle beams and on accelerator technology that can broadly benefit fields both within and outside of HEP. Additional funding is requested to start new R&D effort on ion beam acceleration for medical use, the development of high power/high repetition rate lasers for the manipulation of charged particle beams, and higher efficiency RF power sources. Funding is also sought to allow the accelerator industry access to specialized test facilities at the national laboratories.	+9,253
SBIR/STTR: Funding is provided in accordance with the legislatively directed percentage of HEP operating budgets.	-1,024
Construction: Funding is provided consistent with the planned profile for construction of the Muon to Electron Conversion Experiment. No construction funding is provided for LBNE.	-26,000
Total, High Energy Physics	**-52,521**

Basic and Applied R&D Coordination

Many applications of technology developed by HEP research have been unforeseen. Although it has been recognized that many of these technology developments have transformative impacts in the areas of national security, medicine, energy and environment, industry, and discovery science (including accelerator science), there has been no systematic way of enhancing technology transfer to these other fields.

In order to better leverage possible future applications of accelerators, as well as key technical areas, HEP requested that SLAC convene the Accelerator Stewardship Task Force consisting of accelerator R&D experts drawn from universities, national laboratories, and industry to help identify specific research areas and infrastructure gaps where HEP investments could have significant impacts beyond the "traditional" HEP program.

HEP coordinates its program with other offices and agencies with related programs and missions. The U.S. LHC program is supported by HEP and NSF Physics Division and overseen by a Joint Oversight Group (JOG). Dark matter research is also jointly sponsored by those agencies, and the agencies are coordinating their planning on next generation experiments. Both HEP and NSF Physics use the High Energy Physics Advisory Panel (HEPAP) as part of their advisory structure. HEP also coordinates with NSF Astronomy on the Dark Energy Survey experiment and the Large Synoptic Survey Telescope Project, each of which is overseen by a JOG. Both agencies as well as NASA receive advice from the Astronomy and Astrophysics Advisory Committee on areas of joint interest.

HEP coordinates with other offices with the Office of Science to identify common interests and to avoid duplication. For example, Lattice Quantum Chromodynamics is a technique to perform calculations involving the strong interaction, which binds quarks into hadrons such as protons, neutrons, and pions studied by HEP; and protons and neutrons into nuclei studied by NP. HEP and NP jointly support acquisition and operation of the dedicated computer hardware needed for these calculations but separately support research on the different topics of concern to each program.

Program Accomplishments

FY 2013 saw confirmations of the paradigm-shifting accomplishments of FY 2012 on many frontiers of particle physics.

LHC experiments confirm the Standard Model Higgs boson has been found (Energy Frontier). The LHC experiments announced discovery of a new particle compatible with the long-sought Standard Model Higgs boson in 2012. In 2013, additional data made the signal for the Higgs Boson indisputable and provided additional measurements of its fundamental properties consistent with the predictions of the Standard Model.

Daya Bay Experiment makes the first definitive measurement of the remaining unknown neutrino mixing angle (Intensity Frontier). Using a partially complete infrastructure, the Daya Bay collaboration led by U.S. and Chinese physicists reported in 2012 a first measurement of the "mixing angle" responsible for changing the flavor of electron antineutrinos over short baselines. In 2013, after careful calibration and systematic studies of the antineutrino detectors, the Daya Bay collaboration announced a new result measuring both the amplitude and frequency of this oscillation and providing precision values for the neutrino mixing angle and the associated mass splitting between the neutrino states.

Electron acceleration using beam-based plasma wakefields (Advanced Technology R&D). An experiment at the FACET facility at SLAC National Accelerator Laboratory demonstrated that accelerator-quality electron beams are capable of reaching high energies much faster than in conventional accelerators by riding on a wake in a plasma created by another electron beam. This is the first demonstration of beam-based plasma wakefield acceleration that maintains a good energy spread in a high-energy accelerated beam.

In addition, the so-called *"AdS/CFT (anti de Sitter/conformal field theory) correspondence,"* originally conceived by HEP-supported theorists in 1997, continues to grow in value. This technique has not only provided hitherto-inaccessible insights into the nature of Quantum Chromodynamics and its supersymmetric extensions, but has also increasingly been applied to other areas, including nuclear physics experiments performed at the Relativistic Heavy Ion Collider and condensed matter theories to explain the complex behavior of electrons in superconductors.

High Energy Physics
Energy Frontier Experimental Physics

Description

The Energy Frontier Experimental Physics subprogram supports LHC research and final analysis of data from the Tevatron experiments at Fermilab with the goal of determining to what extent the Standard Model correctly describes the natural world. Discoveries made and experimental techniques introduced at the Tevatron over the years are now the foundation for much of the LHC research program.

Research activities at the Energy Frontier in FY 2015 will be focused primarily on the LHC. In 2015, the LHC experiments will come back on-line after a planned shutdown that began in FY 2013 to bring the LHC to the full design energy of at least 13 TeV. Data collected during this period will be used to determine answers to many fundamental questions in particle physics, including:

- *Have we really discovered the Standard Model Higgs boson?*

  The Higgs boson is thought to be responsible for generating the mass for all fundamental particles. In July 2012, CERN announced the discovery of a new particle consistent, within the limited statistical accuracy, with being the Standard Model Higgs boson. Since the discovery, experiments at the LHC continue to actively measure the particle's properties to ascertain whether it is indeed the Standard Model Higgs boson. In March 2013, new results strongly indicated consistency with the Standard Model picture. However, more data are required to precisely measure its properties. Through such studies, scientists will be able to establish the particle's exact character or understand if the initial observation is the result of new physics beyond the Standard Model.

- *Are there undiscovered principles of nature, such as new symmetries or new physical laws governing the nature and interaction of fundamental particles?*

  Researchers at the LHC hope to find evidence of what lies beyond the Standard Model or significantly constrain postulated modifications to the Standard Model such as supersymmetry, mechanisms for black hole production, extra dimensions, and other exotic phenomena. With the start of the second run in FY 2015, the LHC detectors will be much more sensitive to deviations from the Standard Model due to the increase in energy from 8 TeV to at least 13 TeV.

The LHC hosts two large multi-purpose particle detectors, CMS and ATLAS used by large collaborations of international scientists. U.S. researchers make up approximately 20% of the ATLAS collaboration and approximately 30% of the CMS collaboration and play critical leadership roles in all aspects of each experiment.

The Energy Frontier Experimental Physics subprogram also supports the LHC detector operations program, which covers the maintenance of U.S. supplied detector systems for the ATLAS and CMS detectors at the LHC and the U.S. based computer infrastructure for the analysis of LHC data by U.S. physicists.

Research

University-based Energy Frontier research is carried out by groups at over 60 institutions performing experiments at the LHC and legacy analyses of data collected at the Tevatron. Grant-supported scientists typically constitute about 50–75% of the personnel needed to create, run, and analyze an experiment, usually working in collaboration with other university and laboratory groups. Grant-based research efforts are selected based on external comparative peer review; funding allocations take into account the quality and scientific priority of the research proposed. Energy Frontier research also supports physicists from five national laboratories. These are typically large groups that also have significant responsibilities for detector operations, maintenance, and upgrades, particularly at the laboratories that host large computing and analysis-support centers. HEP conducted an external peer review of laboratory research groups in this activity in 2012, and findings from this review were used to inform the funding decisions in subsequent years. HEP will review this activity again in 2015 and evaluate progress.

Facility Operations and Experimental Support

U.S. LHC Detector Operations supports the maintenance of U.S. supplied detector systems for the CMS and ATLAS detectors at the LHC and for the U.S. based computer infrastructure used by U.S. physicists to analyze LHC data, including Tier 1 computing centers at Fermi National Accelerator Laboratory (Fermilab) and the Brookhaven National Laboratory (BNL). There are 11 LHC Tier 1 computing centers around the world. They provide round-the-clock support for the Grid, and are responsible for storing a proportional share of raw and reconstructed data, as well as performing large-scale data reprocessing and storing the corresponding output.

Projects

This activity will support the fabrication of major items of equipment (MIE) for the Energy Frontier subprogram, namely upgrades to the ATLAS and CMS detectors.

CERN plans to upgrade the LHC machine to produce 2-3 times the instantaneous luminosity currently delivered. This work is planned to be completed in 2018. The objective of the two detector upgrade projects is to enable each experiment to fully exploit the physics opportunities offered by the LHC for exploration of new physics and to make precision measurements of properties of known phenomena.

A new MIE is requested in FY 2015 for the fabrication of the ATLAS Detector Upgrade Project. Upgrades are needed to the Muon Subsystem, the Liquid Argon Calorimeter Detector and Trigger and Data Acquisition System to take advantage of the increased luminosity.

A new MIE is requested in FY 2015 for the fabrication of the CMS Detector Upgrade Project. Upgrades are needed to the Pixelated Inner Tracking Detector, the Hadron Calorimeter Detector, and Trigger System to take advantage of the increased luminosity.

Energy Frontier Experimental Physics

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Research		
U.S. university and laboratory scientists will continue the analysis of LHC data taken during the first 2009–2012 run. They will also participate in the maintenance of the detectors during the LHC shutdown in order to optimize the detector's performance in the next run at higher energy and higher data rates. Final analyses of Tevatron data are supported.	The LHC will resume operations in FY 2015 after completion of machine repairs and detector maintenance to allow collecting data at energies of at least 13 TeV. U.S. university and laboratory scientists will focus on continuing research activities in conducting high-profile studies, including precision measurements of the recently discovered Higgs boson and search for new physics.	Funding for the Energy Frontier research is reduced as the Tevatron research program is completed and due to overall programmatic reductions in research activities to support current and future experimental capabilities. Some research staff previously supported under Research will be redirected to the LHC Detector Upgrade projects.
Facility Operations and Experimental Support		
During FY 2014, the LHC is shut down for maintenance. There are significant maintenance activities for the detectors. The major computer centers at Fermilab and BNL are being used for continuing analysis of the existing data and the simulation of the data expected at higher energies in the next run. The maintenance of dedicated network links between CERN and the computing centers is also supported.	The LHC run resumes in FY 2015, and supported activities shift to routine maintenance and calibration of the detectors. The computing centers will shift to processing of the newly acquired data in addition to data analysis and simulation.	Major maintenance activities carried out in FY 2014 allow for a small reduction in operating costs in FY 2015.
Projects		
	In order to take advantage of the increased LHC luminosity, two new MIEs are requested. The LHC ATLAS Detector Upgrade will provide upgrades to the Muon Subsystem, the Liquid Argon Calorimeter Detector, and Trigger and Data Acquisition System.	Two new MIE projects are started and funds are provided accordingly, to support engineering, design, and fabrication for the two LHC Detector Upgrades.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
	The CMS Detector Upgrade will provide upgrades to the Pixelated Inner Tracking Detector, the Hadron Calorimeter Detector, and Trigger System.	

High Energy Physics
Intensity Frontier Experimental Physics

Description

The Intensity Frontier Experimental Physics subprogram investigates some of the rarest processes in nature including unusual interactions of fundamental particles or subtle effects requiring large data sets to observe and measure. This subprogram in particular shares some deep intellectual connections with Nuclear Physics. Generally this HEP subprogram focuses on using high-power particle beams or other intense particle sources to make precision measurements of fundamental particle properties. These measurements in turn probe for new phenomena than cannot be directly observed at the Energy Frontier, either because they occur at much higher energies and their effects only be seen indirectly; or because they are due to interactions that are too weak to be detected in a high-background environment.

Activities at the Intensity Frontier in FY 2015 will be focused primarily on operating new and existing facilities while continuing investments to maintain a world-leading program into the future. These facilities and investments are concentrated primarily in the areas of neutrino and muon physics at Fermilab. The NOvA neutrino detector will be completed in FY 2014 and have a full run in FY 2015 with the upgraded NuMI beam, the world's most powerful neutrino beam. Operation of the Daya Bay Reactor Neutrino Experiment in China will continue. Fabrication funding continues for the Muon g-2 Experiment. Data collected during this period will be used to determine answers to fundamental questions in particle physics, including:

- *What are neutrinos telling us?*

  Of all known particles, neutrinos are perhaps the most enigmatic and certainly the most elusive. The three known varieties of neutrinos were all discovered by HEP researchers working at U.S. facilities. HEP supports research into fundamental neutrino properties that may reveal important clues about the unification of forces and the very early history of the universe.

- *What happened to the antimatter?*

  The universe today appears to contain very little antimatter. Antimatter is continually produced by naturally occurring radioactivity, only to undergo near immediate annihilation. The Big Bang, however, should have produced equal amounts of both matter and antimatter, which agrees with the study of high-energy collisions in the laboratory, so the lack of antimatter observed today is a mystery. Precise Intensity Frontier measurements of the subtle asymmetries present in the weak interactions of fundamental particles may shed light on how this matter-antimatter asymmetry arose.

<u>Research</u>

The HEP experimental research activity at the Intensity Frontier consists of groups at over 50 academic institutions and physicists from eight national laboratories, performing experiments at a variety of locations. The laboratory groups typically have a portfolio of responsibilities ranging from detector operations and maintenance to computing and data analysis. Research efforts will be selected based on a comparative peer-review process in order to maintain activities with the highest scientific merit and potential impact. HEP conducted an external peer review of all laboratory research groups in this subprogram in 2013, and findings from this review will be used to inform the funding decisions in subsequent years. The next review is planned for FY 2016.

<u>Facility Operations and Experimental Support</u>

There are several distinct facility operations and experimental support efforts in the Intensity Frontier subprogram. The largest is the Fermilab Accelerator Complex User Facility. The operation of the accelerator, detectors, and computing are included in this activity. Maintenance and improvements of the facility is supported (General Plant Project (GPP) and Accelerator Improvement Project (AIP) funding). In FY 2015, the major experimental efforts will be the NOvA and

MicroBooNE experiments utilizing the NuMI and Booster neutrino beams. Operation of the Homestake Mine for the LUX and Majorana demonstrator experiments is provided under this activity.

Projects

This activity supports the fabrication of major items of equipment for the Intensity Frontier subprogram. It also covers preconceptual R&D for proposed new Intensity Frontier effort and the other project costs (OPC) of line item construction for the Intensity Frontier.

The Muon g-2 project is an MIE to provide equipment needed to adapt an existing muon storage ring from Brookhaven National Laboratory (BNL) to utilize the higher intensity proton beam at Fermilab. The storage ring was successfully moved from BNL to Fermilab in FY 2013. New detectors, a muon production target, and muon beam transport will be fabricated.

The Belle II Project is an MIE to build detector subsystems for the Belle II detector at the High Energy Accelerator Research Organization in Tsukuba, Japan, known as KEK. KEK is upgrading their B-Factory to produce an order of magnitude more data. The U.S. is providing new particle identification detectors designed to handle the increased data rates.

The Other Project Costs for LBNE are funded to support the project team working on the design in response to recommendations of the community planning effort to be completed in FY 2014.

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Research		
Datataking and analysis with the completed NOvA detector will begin to enable key measurements of neutrino properties. In parallel, the MicroBooNE experiment will study important low energy neutrino cross sections using the Booster neutrino beam at Fermilab. Ongoing datataking and physics analysis with the ongoing experiments of Daya Bay, Tokai to Kamioka (T2K), Main Injector Neutrino Oscillations Study (MINOS+) and MINERvA; research and development for the future experiments of Muon g-2, Mu2e and LBNE are supported. Final analyses of the data from the Double Chooz Reactor Neutrino and MiniBooNE experiments will be completed. Funding is reduced for the SLAC support of BaBar legacy analyses as they are completed.	Commissioning of the Belle II detector, datataking and physics analysis with the ongoing experiments of NOvA, MicroBooNE, T2K, MINOS+ and MINERvA; research and development for the future experiments of Muon g-2, Mu2e are all supported. LBNE design work will reflect the recommendations of the community planning exercise to be completed in FY 2014. Research activities for Daya Bay Reactor Neutrino experiment will begin to ramp down. Funding is further reduced for the SLAC BaBar legacy analyses as they are completed.	Intensity Frontier research is decreased to offset investments in new facilities.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Facility Operations and Experimental Support		
Fermilab will operate the accelerator complex for a 4,500 hour run for neutrino physics. GPP projects at the Fermilab accelerator complex to develop the common infrastructure needed to carry out muon experiments are fully underway and supported. Funding is provided for safety and maintenance activities and support of the LUX and Majorana demonstrator experiments at the Homestake Mine.	The Fermilab Accelerator complex will continue to run for neutrino physics. The GPP projects to support the muon physics program ramp down and AIP projects ramp up. There are two GPP projects in the Muon Campus (MC) complex in FY 2015 (Beamline Enclosure and MC Infrastructure) whose funding is planned at $6,100,000. In addition, there are four AIP projects in the Muon Campus in FY 2015 (Cryogenics, Recycler RF, Beam Transport and Delivery Ring) whose funding is planned at $13,300,000. The Homestake Mine is operated for the LUX and Majorana demonstrator experiments. No funding is provided to SLAC to decommission the BaBar detector since that work has been completed.	Total funding for Facility Operations decreases because of the decommissioning of the SLAC B Factory and the completion of the analysis of its data set.
Projects		
The Muon g-2 project is a new MIE in FY 2014. Funding is also provided to continue Belle II activities. Funding for the Mu2e OPC was completed in FY 2013. Other Project Costs for LBNE are included. Preconceptual R&D for possible upgrade of the front-end of the Fermilab accelerator complex to significantly enhance the beam power is included.	FY 2015 is the final year of funding for Belle II detector upgrade. All other activities supported in FY 2014 continue to be supported.	Belle II ramps down by $7,030,000 as the project is completed. Funding for preconceptual R&D on the Fermilab accelerator upgrade is reduced by $5,000,000.

High Energy Physics
Cosmic Frontier Experimental Physics

Description

The Cosmic Frontier Experimental Physics subprogram supports the study of high energy physics through measurements of naturally occurring cosmic particles and observations of the universe. The activities in this subprogram use diverse tools and technologies, from ground-based telescopes and space-based experiments to large detectors deep underground, to probe fundamental physics questions and offer new insight about the nature of dark matter, dark energy and other phenomena. In FY 2015, a varied suite of complementary, staged experiments are planned that will lead to measurements with greater precision as the operations and analysis of current experiments continues, while the next generation of experiments are being planned and built.

Experiments in this subprogram can be classified into three main categories: direct-detection searches for dark matter; studies of the nature of dark energy; and measurements of high-energy cosmic and gamma rays to search for indirect signals of dark matter and the presence of primordial antimatter and other fundamental phenomena. Data collected will be used to determine answers to fundamental questions in particle physics, including:

- *How can we solve the mystery of dark energy?*

  Observations of supernovae suggest that, for approximately the last six billion years, the universe has been expanding at an accelerating rate due to a mysterious “dark energy” that appears to overcome gravitational attraction. This acceleration was discovered in 1998 as a result of observations made by HEP-supported researchers among others. The Nobel Prize in Physics in 2011 was awarded for the discovery of the acceleration of the expansion of the universe.

- *What is dark matter?*

  A wide variety of astronomical data suggest that there could be large quantities of matter in the universe unexplained by the Standard Model. This dark matter, so-called because it does not appear to emit electromagnetic radiation that we can detect, played a dominant role in the formation of structures in the Universe. Direct-detection experiments search for dark matter particles’ rare interactions with atomic nuclei, while indirect-detection observatories search for signatures in high-energy cosmic particles.

Research

The Cosmic Frontier experimental research program consists of groups at over 35 academic and research institutions and 7 national laboratories performing experiments at a wide variety of locations. These groups, as part of scientific collaborations, typically have a broad portfolio major of responsibilities and leadership roles including experimental design, fabrication, commissioning, operations, and maintenance, as well as computing and data analysis on the experiments in the subprogram. Research efforts will be selected based on a comparative peer-review process in order to maintain activities with the highest scientific merit and potential impact. HEP conducted an external peer review of all laboratory research groups in this subprogram in 2013, and findings from this review are being used to inform the funding decisions in subsequent years.

Facility Operations and Experimental Support

This activity supports the personnel, data processing, and other expenses necessary for the maintenance, operations, and data production of Cosmic Frontier experiments. Many experiments have large multi-national collaborations and DOE’s fraction of the support cost is based on the magnitude of U.S. roles and responsibilities. In addition, there are DOE-only experiments and partnerships with NSF and NASA. HEP conducted a scientific peer review of Cosmic Frontier operations in 2012. Findings from this review are being used to inform decisions concerning the continuation of specific activities in subsequent years.

Projects

This activity supports all costs for design and fabrication of Cosmic Frontier projects, including major items of equipment (MIEs) and small experiments. The FY 2015 Request supports the 3 billion pixel precision camera (LSSTcam), which is the DOE contribution to the DOE-NSF LSST Project.

Cosmic Frontier Experimental Physics

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Research		
U.S. university and laboratory scientists participate in datataking and analysis of the current experiments, including cosmic-ray experiments, high-energy gamma-ray telescopes, dark energy surveys such as the Dark Energy Survey (DES) and the Baryon Oscillation Spectroscopic Survey (BOSS), and the first generation dark matter (DM-G1) experiments. There will be a review of currently funded R&D efforts on DM-G2 experiments that are developing conceptual designs to determine which are ready to proceed to preliminary design.	Research activities continue on the operating experiments and in support of projects in the subprogram. Data analysis continues on BOSS, which completes its survey in FY 2014.	Research efforts decrease as R&D and design efforts for the LSSTcam move fully to MIE fabrication efforts.
Facility Operations and Experimental Support		
Telescope operations end for BOSS with data processing and analysis expected to continue for another year. Operations continue for ongoing cosmic ray and high-energy gamma ray experiments as well as DES, which started its survey at the end of FY 2013.	The currently running dark matter searches complete operations, with data processing and analysis expected to continue for another year. Operations are supported for AMS-II, DES, and the Fermi Gamma Ray Space Telescope.	Funding for operations decreases slightly as the data analysis for small experiments completed in recent years begins to ramp down.
Projects		
LSSTcam fabrication begins.	LSSTcam fabrication activities continue to ramp up ($35,000,000). Design work will continue on the DM-G2 experiments selected in FY 2014.	Funding for Projects ramps up to support fabrication for LSSTcam and R&D related project costs.

High Energy Physics
Theoretical and Computational Physics

Description

The Theoretical and Computational Physics subprogram provides the mathematical, phenomenological, and computational framework to understand and extend our knowledge of the dynamics of particles and forces, and the nature of space and time. This research is essential for proper interpretation and understanding of the experimental research activities described in other HEP subprograms.

This subprogram supports theoretical research ranging from detailed calculations of the predictions of the Standard Model to the formulation and exploration of possible theories of new phenomena such as dark matter and dark energy and the identification of experimental signatures that would validate these new ideas. This subprogram also supports computational approaches to advance understanding of fundamental physical laws describing the elementary constituents of matter and energy, including computational science and simulations for scientific discovery and computing and software tools to enable and advance experimental and theoretical research at the three High Energy Physics frontiers.

Major research thrusts include the search for a more complete theory that goes beyond the Standard Model—in particular, theories that can explain why there are so many "fundamental" particles and forces, why (most of) these particles have mass, and the nature of dark matter and dark energy and how they relate to particle physics.

Theory

The HEP theory research activity supports groups at over 70 academic and research institutions supported by research grants and 7 national laboratory research groups. Both university and laboratory research groups play important roles in addressing the leading research areas discussed above, with laboratory groups typically more focused on data-driven theoretical investigations and model-building, and university groups typically focused on more formal or mathematical theory. Research efforts will be selected based on comparative peer review to maintain the activities with the highest scientific impact and potential. HEP will conduct an external peer review of all laboratory research groups in this subprogram in 2014, and findings from this review are being used to inform the funding decisions in subsequent years.

Computational HEP

Computation is necessary at all stages of a HEP experiment—from planning and constructing accelerators and detectors, to theoretical modeling, to supporting computationally intensive experimental research and large-scale data and data analysis. In addition, scientific simulation and advanced computing help extend the boundaries of scientific discovery to regions not directly accessible by experiments, observations, or traditional theory. Computational HEP supports partnership (SciDAC) projects with the Advanced Scientific Computing Research program, and directed efforts to develop and maintain and HEP specific computational tools (Scientific Computing).

Projects

The Projects activity currently funds acquisition and operation of dedicated hardware for the Lattice QCD (LQCD) computing effort. Since lattice techniques can address both nuclear and high energy physics topics, and to avoid any duplication of effort, this program is managed in partnership with the Office of Nuclear Physics. The LQCD Project provides dedicated computer hardware for the simulation of the strong interaction of gluons and quarks in bound states. Within the HEP program, its goals are most directly applicable to the Intensity and Energy Frontiers, and the results generated by its users are critical for the interpretation of data from the HEP experimental program in these Frontiers.

Theoretical and Computational Physics

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Theory		
This activity funds theoretical research for university and laboratory groups as well as the Particle Data Group.	This activity funds research for university and laboratory groups as well as the Particle Data Group.	Funding is reduced consistent with overall programmatic reductions in HEP Research activities.
Computational HEP		
SciDAC projects will be reviewed for progress toward their milestones in accelerator modeling, computational cosmology, and lattice QCD algorithm and software development. Programmatic emphasis may be modified based on the outcomes of this review.	HEP is currently planning a new solicitation for FY 2015 in partnership with ASCR.	Funding is reduced consistent with overall programmatic reductions in HEP Research activities.
Projects		
The Lattice QCD Project delivers dedicated computer hardware for the simulation of the strong interaction of gluons and quarks in bound states. The hardware is optimized for these calculations and can be either custom hardware or commercial hardware adapted to the task. The current five-year hardware project will be completed in FY 2014.	The Lattice QCD Project is extended. Funds are supplied to continue operation of the existing hardware, while planning for the acquisition of new hardware is carried out.	No new hardware acquisitions are planned for FY 2015.

High Energy Physics
Advanced Technology R&D

Description

The Advanced Technology R&D subprogram fosters world-leading research in the physics of particle beams, accelerator research and development (R&D), and particle detection—all necessary for continued progress in high energy physics. New developments are stimulated and supported through peer reviewed research. This subprogram supports and advances research at all three experimental Frontiers.

Advanced Technology R&D includes particle accelerator, detector, and beam physics areas. Long-term multi-purpose accelerator research, applicable to fields beyond HEP, is carried out under the Accelerator Stewardship subprogram.

HEP General Accelerator R&D

HEP General Accelerator R&D focuses on understanding the science underlying the technologies used in particle accelerators and storage rings, as well as the fundamental physics of charged particle beams. Long-term research goals include developing technologies to enable breakthroughs in particle accelerator size, cost, beam intensity, and control.

This activity supports research at 8 DOE national laboratories and about 30 academic or other research institutions. Funding is awarded based on external comparative peer reviews. The program also trains new accelerator physicists with approximately 50 graduate students supported per year through research grants. Graduate level training for students and laboratory staff in areas of accelerator physics and technology is supported in this program.

HEP Directed Accelerator R&D

HEP Directed Accelerator R&D supports innovative technologies for possible future HEP accelerator projects, with proof-of-principle demonstrations, prototype component development, and other milestones advancing technical readiness. This includes R&D and prototyping to bring new concepts to a stage of engineering readiness where they can be incorporated into existing facilities or be applied to the design of new facilities. Research efforts within this activity are generally limited in time and have concrete milestones. The components of the HEP Directed Accelerator R&D activity are the LHC Accelerator Research Program (LARP) and the Muon Accelerator Program (MAP).

LARP is carrying out R&D needed for possible U.S. deliverables to the High Luminosity LHC (HL-LHC) that CERN is planning to begin building late in this decade. LARP is investigating how to build niobium-tin superconducting magnets to decrease the size of the beam, "crab" cavities that causes the beam to meet head on rather than at an angle, and feedback systems to keep the intense beams in a compact configuration. MAP is carrying out R&D on the feasibility of creating and accelerating muon beams for either the production of neutrinos or an Energy Frontier lepton collider. It is necessary to determine if very high field magnets (over 30 Tesla) can be built and whether RF cavities can be operated inside high field magnets.

Detector R&D

Detector R&D addresses the need for continuing development of the next generation instrumentation and detectors at the Energy, Intensity, and Cosmic Frontiers. New instrumentation and detectors must be developed with increased capabilities while keeping the cost and time from conception to operation at a minimum. To meet these challenges, HEP actively supports investment in innovative, generic instrumentation and detector research with the potential for wide applicability and/or high payoff. This activity supports research at 6 DOE national laboratories and about 20 academic or other research institutions.

Facility Operations and Experimental Support

Facility Operations and Experimental Support provides operations funding for proposal-driven user facilities like the Facility for Advanced Accelerator Experimental Tests (FACET), as well as laboratory experimental and test facilities, including the Berkeley Lab Laser Accelerator (BELLA) facility and the Superconducting Radio-Frequency (SRF) fabrication and test facilities at Fermilab. BELLA, FACET, and the SRF infrastructure at Fermilab are all in operation. FACET supports experiments driven by its high-energy, ultra-short electron beam, including plasma wakefield acceleration, dielectric wakefield acceleration, terahertz radiation generation, beam diagnostics, and ultra fast magnetic switching in materials.

Advanced Technology R&D

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
HEP General Accelerator R&D		
Supports research needed to develop new accelerators for use by HEP. Topics include novel acceleration concepts, beam instrumentation, beam physics and simulation, superconducting magnets, radiofrequency power sources, and superconducting radiofrequency accelerator cavities.	All topics for FY 2014 continue to be supported, but there is a shift in emphasis as some of the accelerator personnel with expertise in superconducting magnets, beam simulations, and beam physics are being redirected to support HEP Directed Accelerator R&D.	The decrease in funding is due to overall reduction in HEP research and continued redirection of effort to HEP Directed Accelerator R&D.
HEP Directed Accelerator R&D		
LARP is beginning a program to demonstrate the large aperture high gradient focusing magnets can be built with niobium-tin superconductor. MAP studies the operation of RF accelerating cavities in magnetic fields, a critical technology for the collection of muons into beams usable in an accelerator.	LARP will develop a prototype superconducting quadrupole magnets with the large apertures needed to increase luminosity at the LHC. MAP will be commissioning the Muon Ionization Cooling Experiment (MICE) that will demonstrate critical technologies for the collection of muons.	The increase in funding represents a shift of funding from General Accelerator R&D to support the timely delivery of LARP and MAP prototypes and experiment tests.
Detector R&D		
The LHC and future lepton colliders need radiation hardness and fast readout, so R&D on those topics is supported. Very large scale dark matter search experiments require detectors with very low radioactive impurities as well as lower cost per volume, and R&D on these topics is given high priority. The Large Area Picosecond Photodetector (LAPPD), an example of focused detector R&D, will continue to be supported.	Research activities will continue at U.S. universities and national laboratories. HEP programmatic decisions informed by the community planning exercise to be completed in FY 2014 will be a factor in setting priorities in detector development at a time of budget constraints.	The decrease in funding is due to the shift of funding to current and future facilities activities.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Facility Operations and Experimental Support		
These funds support activities for FACET, BELLA and SRF Infrastructure. In FY 2014, FACET plans 2,800 hours of runtime, delivering beam for peer reviewed experiments.	Support for activities at FACET, BELLA and SRF Infrastructure is held approximately constant.	The increase primarily supports FACET operations.

Description

This subprogram supports long-term accelerator R&D that underpins future accelerator concepts and technologies for applications that may extend beyond high energy physics. HEP manages this program in consultation with other Office of Science programs, including Nuclear Physics and Basic Energy Sciences, that develop and build particle accelerators.

HEP and other Office of Science programs will continue to conduct programmatic near- and mid-term R&D on accelerator and beam physics issues related to the scientific facilities they operate. This subprogram is not intended to replace those directed R&D efforts, which are driven by program-specific goals and priorities.

This program provides support for research and increased access for non-traditional users to the laboratory accelerator test facilities to help advance applications in energy and the environment, medicine, industry, national security, and discovery science.

Accelerator Stewardship will pursue targeted R&D to develop new applications of accelerator technology with broad applicability. Initial workshops have identified two target application areas with broad impact: accelerator technologies for ion beam therapy of cancer and laser technologies for accelerators. A third target area in Energy and Environmental applications of accelerator technology is being developed. As the program evolves, new and cross-cutting areas of research will be developed based on strategic opportunities identified by the communities that benefit from particle accelerator technologies, as well as technology practitioners, including possible applications in basic science, medicine, security, and energy.

Research

This research category supports activities that have been identified for applications in areas broader than just HEP. Research is conducted at national laboratories and universities. The stewardship program focuses on long-term accelerator R&D that promotes scientific innovations to enable breakthroughs in particle accelerator size, cost, beam intensity, and control. This activity supports approximately 20 university grants in broadly applicable advanced accelerator science, beam physics and related technologies.

Facility Operations and Experimental Support

The Accelerator R&D Stewardship subprogram supports facility operations and experimental support at the Accelerator Test Facility (ATF) at BNL. Experiments at ATF are studying the interactions of high power electromagnetic radiation and high brightness electron beams, including free-electron lasers and laser acceleration of electrons and the development of electron beams with extremely high brightness, photo-injectors, electron beam and radiation diagnostics and computer controls. Beam time at the ATF is awarded based on a merit-based peer review process.

Accelerator Stewardship

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Research		
Based upon an internal Office of Science review, a number of activities are moved into the Accelerator Stewardship subprogram because of their potential applicability beyond the HEP program. The activities include accelerator R&D efforts at national laboratories, such as beam physics and accelerator modeling and computation at SLAC and PPPL.	Continue to support research activities at laboratories and universities. Initiate research support for selected technology areas such as laser, ion-beam therapy and green RF sources that have been identified through Office of Science led workshops.	Funding is increased to support new research activities for selected accelerator technologies.
Facility Operations and Experimental Support		
Supports facility operation at the ATF and modest incremental support for FACET operations for stewardship research.	Supports facility operation of the ATF for a broad program of long-term accelerator research.	Support experimental operation for ATF at approximately constant level, and the incremental support of FACET is shifted to Advanced Technology R&D.

High Energy Physics
SBIR/STTR

Description

The SBIR/STTR amount is adjusted to mandated percentages for non-capital funding.

Activities and Explanation Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
SBIR/STTR		
SBIR/STTR funding is set at 3.2% of non-capital funding in FY 2014.	In FY 2015, SBIR/STTR funding is set at 3.3% of non-capital funding.	The SBIR/STTR amount is adjusted to mandated percentages for non-capital funding.

Description

The Muon to Electron Conversion Experiment (Mu2e) will be built at Fermilab and is an important component of the Intensity Frontier subprogram. It will utilize a proton beam to produce muons and determine if those muons can change into electrons. There is no mechanism for such interactions of charged leptons (called flavor changing) in the Standard Model, but flavor-changing processes have been observed in neutrinos. Evidence of muon to electron flavor change would further probe this physics beyond the Standard Model.

The Mu2e CD-1 was approved on July 11, 2012. Preliminary engineering design for Mu2e has commenced. PED funds in FY 2013–2014 will be used to complete the engineering design, and construction funds in FY 2014 will be used to initiate long-lead procurement of technical materials in order to reduce cost and schedule risk. The project is planned to be baselined (CD-2) in FY 2014.

Construction

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Long Baseline Neutrino Experiment		
Funding is provided to support design activities.	Construction funding is not requested in FY 2015.	Funding is reduced while HEP develops program plans in response to recommendations of the community planning effort to be completed in FY 2014.
Muon to Electron Conversion Experiment		
Funding of $15,000,000 is provided for design. Funding of $20,000,000 is provided for construction. Critical Decisions CD-2, 3A and 3B are planned during FY 2014. Critical Decision CD-3A approval will allow advance procurements of superconducting solenoid magnet conductor and solenoid prototypes, as well as site preparation work.	Construction funds are requested for construction of the detector hall and fabrication of the accelerator beamline and detector components.	Funding is provided consistent with the established project profile.

High Energy Physics
Performance Measures

In accordance with the GPRA Modernization Act of 2010, the Department sets targets for, and tracks progress toward, achieving performance goals for each program. For more information, refer to the Department's FY 2013 Annual Performance Report. The following table shows the targets for FY 2013 through FY 2015.

	2013	2014	2015
Performance Goal (Measure)	**HEP Facility Operations—Average achieved operation time of HEP user facilities as a percentage of total scheduled annual operation time**		
Target	≥ 80%	≥ 80%	≥ 80%
Result	Not Met	TBD	TBD
Endpoint Target	Many of the research projects that are undertaken at the Office of Science's scientific user facilities take a great deal of time, money, and effort to prepare and regularly have a very short window of opportunity to run. If the facility is not operating as expected the experiment could be ruined or critically setback. In addition, taxpayers have invested millions or even hundreds of millions of dollars in these facilities. The greater the period of reliable operations, the greater the return on the taxpayers' investment.		
Performance Goal (Measure)	**HEP Construction/MIE Cost & Schedule— Cost-weighted mean percentage variance from established cost and schedule baselines for major construction, upgrade, or equipment procurement projects**		
Target	< 10%	< 10%	< 10%
Result	Met	TBD	TBD
Endpoint Target	Adhering to the cost and schedule baselines for a complex, large scale, science project is critical to meeting the scientific requirements for the project and for being good stewards of the taxpayers' investment in the project.		

	2013	2014	2015
Performance Goal (Measure)	**HEP Neutrino Model—Carry out series of experiments to test the standard 3-neutrino model of mixing**		
Target	Measure mixing angle between muon neutrinos and electron neutrinos ($\sin^2(2\theta_{13})$) by measuring disappearance of electron antineutrinos with Daya Bay Reactor Experiment (should have uncertainty of 0.0075 or smaller)	Begin operation of full NOvA detector using neutrino beam from Fermilab for purpose of measuring mixing angle between muon neutrinos and electron neutrinos ($\sin^2(2\theta_{13})$) using the appearance of electron neutrinos.	Physics analyses results from the first year of datataking with the full detector will be presented by the NOvA and MicroBooNE experimental collaborations at the FY 2015 summer conferences.
Result	Met	TBD	TBD
Endpoint Target	Similar to quarks, the mixing between neutrinos is postulated to be described by a unitary matrix. Measuring the independent parameters of this matrix in different ways and with adequate precision will demonstrate whether this model of neutrinos is correct. Such a model is needed to correctly extract evidence for CP violation in the neutrino sector.		

High Energy Physics Capital Summary ($K)

	Total	Prior Years	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Capital Operating Expenses Summary							
Capital equipment	n/a	n/a	36,327	50,222	50,222	71,832	+21,610
General plant projects (GPP)	n/a	n/a	20,700	14,548	14,548	9,826	-4,722
Accelerator improvement projects (AIP)	n/a	n/a	2,100	6,200	6,200	13,300	+7,100
Total, Capital Operating Expenses	**n/a**	**n/a**	**59,127**	**70,970**	**70,970**	**94,958**	**+23,988**
Capital Equipment							
Major items of equipment							
Energy Frontier Experimental Physics							
LHC ATLAS Detector Upgrades[a]	25,500	0	0	0	0	7,500	+7,500
LHC CMS Detector Upgrades[b]	25,500	0	0	0	0	7,500	+7,500
Intensity Frontier Experimental Physics							
NOνA (TPC $278,000)	206,860	187,380	19,480	0	0	0	0
MicroBooNE[c] (TPC $19,900)	14,760	8,903	5,857	0	0	0	0
Belle II[d]	8,970	0	0	8,000	8,000	970	-7,030
Muon g-2 Experiment[e]	27,150	0	0	2,000	2,000	9,000	+7,000
Cosmic Frontier Experimental Physics							
High Altitude Water Cherenkov (HAWC)[f]	3,000	1,500	1,500	0	0	0	0

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[a] Critical Decision CD-1 for the LHC CMS Detector Upgrade Project was approved on October 17, 2013. The TPC range is $29,200,000 to $35,900,000.

[b] Critical Decision CD-1 for the LHC ATLAS Detector Upgrade Project was approved on October 17, 2013. The TPC range is $32,200,000 to $34,500,000.

[c] The MicroBooNE Project received CD-2/3a approval for its performance baseline and long-lead procurements on September 27, 2011. CD-3b approval for all fabrication was on March 29, 2012. The TPC is $19,900,000.

[d] This project is not yet baselined. Critical Decision CD-1 for the Belle II Project's Conceptual Design was approved on September 18, 2012 with a cost range of $12,000,000 to $16,000,000. Initial long-lead procurement was approved (CD-3A) on November 8, 2012.

[e] Critical Decision CD-1 for the Muon g–2 Project was approved on December 19, 2013. The TPC range is $43,000,000 to $50,100,000.

[f] The HAWC project falls below the $10,000,000 TPC threshold that required a CD-0. DOE funding was completed in FY 2013, with the project completed and operations starting in FY 2014.

	Total	Prior Years	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Large Synoptic Survey Telescope (LSSTcam) Camera[a]	159,600	0	0	22,000	22,000	35,000	+13,000
Total MIEs	**n/a**	**n/a**	**26,837**	**32,000**	**32,000**	**59,970**	**+27,970**
Other capital equipment projects under $2 million TEC	n/a	n/a	9,490	18,222	18,222	11,862	-6,360
Total, Capital equipment	**n/a**	**n/a**	**36,327**	**50,222**	**50,222**	**71,832**	**+21,610**
General Plant Projects (GPP)							
MC-1 Building	9,000	500	7,500	1,000	1,000	0	-1,000
Muon Campus Beamline Enclosure	9,700	0	400	3,700	3,700	5,600	+1,900
Other projects under $5 million TEC	n/a	n/a	12,800	9,848	9,848	4,226	-5,622
Total, Plant Project (GPP)	**n/a**	**n/a**	**20,700**	**14,548**	**14,548**	**9,826**	**-4,722**
Accelerator Improvement Projects (AIP)							
Muon Campus Cryogenics	9,700	0	1,100	4,200	4,200	2,200	-2,000
Recycler RF Upgrades	8,700	0	600	1,000	1,000	3,900	+2,900
Other projects under $5 million TEC	n/a	n/a	400	1,000	1,000	7,200	+6,200
Total, Accelerator Improvement Projects	**n/a**	**n/a**	**2,100**	**6,200**	**6,200**	**13,300**	**+7,100**

[a] This project is not yet baselined and the OPC/TEC split is not yet determined. This project received CD-1 on April 12, 2012 with a cost range of $120,000,000 to $175,000,000.

Major Items of Equipment Descriptions

Energy Frontier Experimental Physics MIEs:

By 2019, CERN plans to increase the LHC luminosity by 100–200% compared to its 2015–2017 running period. The increase will result in higher particle rates and densities as well as a large increase in the number of overlapping collisions. Consequently, this can lead to more rapid radiation damage to individual detector subsystems, larger volumes of data, and challenging event conditions. In order to cope with these effects and continue to fully exploit the physics opportunities offered at the LHC, the detectors will need upgrades. DOE supported part of the original construction of two of the four LHC detectors (CMS and ATLAS), and proposes to support the upgrade of those detectors to maintain their capabilities at the higher luminosity LHC.

The ATLAS Detector Upgrade Project will be a new MIE in FY 2015. Upgrades are needed to the muon subsystem, the liquid argon calorimeter detector, and the trigger and data acquisition system to take advantage of the increased luminosity. The LHC ATLAS Detector Upgrade Project received CD-1, Approve Alternative and Cost Range, on October 17, 2013, with an estimated cost range of $32,200,000 to $34,500,000 and estimated completion date of FY 2018.

The CMS Detector Upgrade Project will be a new MIE in FY 2015. Upgrades are needed to the pixelated Inner tracking detector, the hadron calorimeter detector, and trigger system to take advantage of the increased luminosity. The LHC CMS Detector Upgrade Project received CD-1, Approve Alternative and Cost Range on October 17, 2013, with an estimated cost range of $29,200,000 to $35,900,000 and estimated completion date of FY 2018.

Intensity Frontier Experimental Physics MIEs:

The *NuMI Off-axis Neutrino Appearance (NOνA) Project* will use the NuMI beam from Fermilab to directly observe and measure the transformation of muon neutrinos into electron neutrinos over a distance of 810 km (500 miles). The project also includes improvements to the Fermilab proton accelerator to increase the intensity of the neutrino NuMI beam to the detector in Ash River, Minnesota. The occurrence of neutrino flavor changes is expected to be much rarer than the phenomenon under study with MINOS. The baseline was approved in September 2008 with a TPC of $278,000,000. A total of $55,000,000 was provided under the Recovery Act to advance the project. Fabrication was approved by CD-3A and CD-3B in FY 2009. Final funding for NOvA was provided in FY 2013. The NOvA Project will complete fabrication (CD-4) in FY 2014.

The MicroBooNE Project began fabrication in FY 2012. This project will build a multi-hundred ton liquid-argon neutrino detector to be used in the Booster neutrino beam at Fermilab for the measurement of low energy neutrino cross-sections. These cross sections will be measured at lower neutrino energy than MINERνA and will be important for future neutrino oscillation experiments such as T2K. This experiment will also be an important demonstration of the efficacy of large-scale liquid argon time projection chambers as neutrino detectors. This is a new technology with improved track resolution and background discrimination. CD-3b approval for all fabrication was on March 29, 2012. The TPC is $19,900,000. Fabrication started in FY 2012 and the last year of funding is FY 2013. The MicroBooNE Project will complete fabrication in FY 2015.

The *Belle II Project* will fabricate detector subsystems for the upgraded Belle detector located at the Japanese B-Factory, which is currently being upgraded to deliver higher luminosity. This project is not yet baselined. Critical Decision CD-1 for Conceptual Design was approved on September 18, 2012. Initial long-lead procurement was approved (CD-3A) on November 8, 2012. The TPC range is $12,000,000 to $16,000,000.

The *Muon g-2 Project* will fabricate an experiment that seeks to improve the measurement of the muon anomalous magnet moment, which is sensitive to new physical interactions such as supersymmetry. The project will repurpose a storage ring from a previous experiment at Brookhaven National Laboratory with upgraded detectors to be located at Fermilab in order to utilize the high intensity proton beam available there to produce the needed muons. CD-1 was approved on December 19, 2013, with a TPC range of $43,000,000 to $50,100,000. Transfer of the BNL storage ring to Fermilab occurred in FY 2013. The Muon g-2 Project plans for CD-2 in FY 2015. Funding in FY 2014 and FY 2015 will pay for project design and the reassembly and testing of the BNL storage ring at Fermilab. New instrumentation for the storage ring will be provided, in part, by in-kind contributions from non-DOE sources including NSF. The Muon g−2 experiment offers a strategic opportunity to search for new physics that may be inaccessible to the LHC.

Cosmic Frontier Experimental Physics MIEs:

The *High Altitude Water Cherenkov (HAWC)* project is for an experiment in Mexico to survey the sky for sources of gamma-rays in the 10–100 TeV range. HAWC's wide field of view and continuous duty cycle will provide unique capabilities that are complementary to other gamma-ray experiments. The project is being carried out in collaboration with NSF and Mexican research institutes. MIE funding for the fabrication started in FY 2012 and completed in FY 2013. The total DOE cost was $3,000,000 and the full project will be completed and start science operations in FY 2014.

The *Large Synoptic Survey Telescope Camera (LSSTcam*) was a new MIE start in FY 2014. It is a digital camera for a next-generation, wide-field, ground-based optical and near-infrared LSST observatory, located in Chile, and is designed to provide deep images of half the sky every few nights. It will open a new window on the universe and address a broad range of topics in astronomy with an emphasis on enabling precision studies of the nature of dark energy. LSST was identified by the National Research Council's (NRC) Astro2010 decadal survey panel as its highest priority ground-based astrophysics initiative. The project is carried out in collaboration with NSF, along with private and foreign contributions. DOE will provide the camera for the facility. CD-1 for the LSSTcam project was approved in April 2012, with an estimated total DOE cost range of $120,000,000–$175,000,000 and estimated completion date of FY 2021.

High Energy Physics Construction Project Summary ($K)

	Total	Prior Years	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Long Baseline Neutrino Experiment							
TEC	TBD	4,000	3,781	16,000	16,000	0	-16,000
OPC	TBD	51,432	14,107	10,000	10,000	10,000	0
TPC	TBD	55,432	17,888	26,000	26,000	10,000	-16,000
Muon to Electron Conversion Experiment							
TEC	209,900	24,000	8,000	35,000	35,000	25,000	-10,000
OPC	23,677	21,177	2,500	0	0	0	0
TPC	233,577	45,177	10,500	35,000	35,000	25,000	-10,000
Total, Construction							
TEC	n/a	n/a	11,781	51,000	51,000	25,000	-26,000
OPC	n/a	n/a	16,607	10,000	10,000	10,000	0
TPC	n/a	n/a	28,388	61,000	61,000	35,000	-26,000

Funding Summary ($K)

	FY 2013 Current	FY 2014 Enacted	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Research	361,766	370,447	352,227	-18,220
Facilities Operations				
Scientific User Facilities Operations	200,023	227,312	216,983	-10,329
Other Facilities	63,553	47,686	47,225	-461
Total, Facilities Operations	**263,576**	**274,998**	**264,208**	**-10,790**
Projects				
Major Items of Equipment	48,687	51,000	65,970	+14,970
Other Projects	23,559	15,894	6,000	-9,894
Construction[a]	28,388	61,000	35,000	-26,000
Total, Projects	**100,634**	**127,894**	**106,970**	**-20,924**
Other	1,547	23,182	20,595	-2,587
Total, High Energy Physics	**727,523**	**796,521**	**744,000**	**-52,521**

[a] Includes Other Project Costs funding for LBNE and Mu2e.

Scientific User Facility Operations ($K)

	FY 2013 Current	FY 2014 Enacted	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Fermilab Accelerator Complex	**$132,928**	**$156,438**	**$152,096**	**-$4,342**
Achieved operating hours	503	N/A	N/A	
Planned operating hours	520	4,500	4,500	0
Optimal hours (estimated)	520	4,500	4,500	0
Percent of optimal hours	100%	100%	100%	
Unscheduled downtime percentage	96%	N/A	N/A	
Total number of users	1,850	1,400	1,400	0
FACET	**$8,589**	**$9,500**	**$9,365**	**-$135**
Achieved operating hours	2,155	N/A	N/A	
Planned operating hours	2,544	2,800	2,800	0
Optimal hours (estimated)	2,544	2,800	2,800	0
Percent of optimal hours	85%	100%	100%	
Unscheduled downtime percentage	15%	N/A	N/A	
Total number of users	141	48	48	0
B-Factory	**$1,594**	**$4,600**	**0**	**-$4,600**
Total number of users	100	100	0	-100
LHC	**$56,912**	**$56,774**	**$55,522**	**-$1,252**
Total number of users	0	0	0	0
Total Facilities	**$200,023**	**$227,312**	**$216,983**	**-$10,329**
Achieved operating hours	2,658	N/A	N/A	
Planned operating hours	3,064	7,300	7,300	0
Optimal hours (estimated)	3,064	7,300	7,300	0
Percent of optimal hours (funding weighted)	96%	100%	100%	
Unscheduled downtime percentage	111%	N/A	N/A	
Total number of users	2,091	1,548	1,448	-100

Scientific Employment

	FY 2013 Actual	FY 2014 Estimate	FY 2015 Estimate	FY 2015 vs. FY 2014
Number of laboratory groups	45	40	40	0
Number of permanent Ph.D.'s (FTEs)	965	955	905	-50
Number of postdoctoral associates (FTEs)	415	410	370	-40
Number of graduate students (FTEs)	530	505	495	-10
Number of Ph.D.'s awarded	110	105	95	-10

11-SC-41, Muon to Electron Conversion Experiment (Mu2e), Fermi National Accelerator Laboratory, Batavia, Illinois
Project is for Design and Construction

1. Significant Changes

The most recent DOE O 413.3B approved Critical Decision (CD) is CD-1 that was approved on July 11, 2012 with a preliminary cost range of $200,000,000–$310,000,000 and CD-4 of FY 2021.

A Federal Project Director with a certification level 4 has been assigned to this project.

This Project Data Sheet (PDS) does not include a new start for the Budget Year.

This PDS is an update of the FY 2013 Reprogramming PDS. In FY 2013, Congress approved a reprogramming[a] that reduced the FY 2013 funding to $8,000,000 from the $22,685,000 that was appropriated. The project had significant carryover of funds from FY 2012. Consequently, the reprogramming did not limit the project's progress in FY 2013, and allowed other activities at Fermilab to be maintained at the planned levels.

Design work was slowed in FY 2013 while several technical issues were resolved. It took longer than expected to find qualified vendors of the advanced superconducting cable required for the project's magnets, and simulation of the detector was improved to provide better input to the experiment's design. Design work is now expected to be completed within budget, but the start of construction will be delayed. The request for construction funds in FY 2015 has been reduced by $7,000,000 relative to the prior year plan. This funding is redistributed into later years.

Critical Decisions CD-2, 3A and 3B are planned during FY 2014. In accordance to DOE O 413.3B, long lead procurements of superconducting solenoid magnet conductor and solenoid prototypes, as well as site preparation work will take place after Critical Decision CD-3A. CD-3B is planned at the end of FY 2014 for initiating civil construction in FY 2015.

2. Critical Decision (CD) and D&D Schedule

(fiscal quarter or date)

	CD-0	CD-1	Design Complete	CD-2	CD-3A	CD-3B	CD-4	D&D
FY 2011	11/24/2009	4Q FY 2010	4Q FY 2012	TBD	N/A	TBD	TBD	TBD
FY 2012	11/24/2009	4Q FY 2011	4Q FY 2013	TBD	N/A	TBD	TBD	TBD
FY 2013	11/24/2009	4Q FY 2012	4Q FY 2014	4Q FY 2013[b]	N/A	4Q FY 2014[b]	4Q FY 2018[b]	N/A
FY 2014	11/24/2009	7/11/2012	2Q FY 2015	2Q FY 2014[b]	3Q FY 2013[b]	4Q FY 2015[b]	2Q FY 2021[b]	N/A
FY 2013 Reprogramming[a]	11/24/2009	7/11/2012	2Q FY 2015	2Q FY 2014[b]	3Q FY 2013	4Q FY 2015[b]	2Q FY 2021[b]	N/A
FY 2015	11/24/2009	7/11/2012	2Q FY 2015	4Q FY 2014[b]	3Q FY 2014	4Q FY 2014[b]	2Q FY 2021[b]	N/A

CD-0 – Approve Mission Need
CD-1 – Approve Alternative Selection and Cost Range
CD-2 – Approve Performance Baseline
CD-3A – Approve Long-Lead Procurement/Limited Construction
CD-3B – Approve Full Construction

[a] The FY 2013 reprogramming was approved by Congress.
[b] Schedule estimates are preliminary since this project has not received CD-2 approval.

CD-4 – Approve Start of Operations or Project Closeout
D&D Start – Start of Demolition & Decontamination (D&D) work
D&D Complete – Completion of D&D work

3. Baseline and Validation Status

(dollars in thousands)

	TEC, Design	TEC, Construction	TEC, Total	OPC Except D&D	OPC, D&D	OPC, Total	TPC
FY 2011	35,000	TBD	TBD	10,000	TBD	TBD	TBD
FY 2012	36,500	TBD	TBD	18,777	TBD	TBD	TBD
FY 2013	44,000	N/A	N/A	24,177	0	24,177	68,177
FY 2014	61,000	162,000	223,000	26,177	0	26,177	249,177
FY 2013 Reprogramming	49,000	162,000	211,000	23,677	0	23,677	234,677
FY 2015	47,000	162,900	209,900	23,677	0	23,677	233,577[a]

4. Project Description, Scope, and Justification

Mission Need

The conversion of a muon to an electron in the field of a nucleus provides a unique window for discovery of charged lepton flavor symmetry violation and allows access to new physics at very high mass scales. The Particle Physics Project Prioritization Panel (P5) recommended this type of experiment for the Intensity Frontier of particle physics. This project provides accelerator beam and experimental apparatus to identify unambiguously neutrinoless muon-to-electron conversion events.

Scope and Justification (11-SC-41, Muon to Electron Conversion Experiment)

This project will construct a new beamline for protons using the existing 8 GeV Booster Synchrotron at Fermilab: a system for producing, transporting and stopping secondary muons (from the proton beam); an experimental detector, a low-mass magnetic spectrometer that can measure the electron momentum with a resolution of order 0.15%; and a new conventional facility to house the secondary production target, muon-stopping beamline, and the detector.

The project is being conducted in accordance with the project management requirements in DOE 413.3B, Program and Project Management for the Acquisition of Capital Assets, and all appropriate project management requirements have been met.

[a] This project has not received CD-2 approval. No construction, other than long-lead procurement and site preparation, will be performed until the project performance baseline has been validated and CD-3B has been approved.

5. Financial Schedule

(dollars in thousands)

	Appropriations	Obligations	Costs
Total Estimated Cost (TEC)			
Design			
FY 2012	24,000	24,000	0
FY 2013	8,000[a]	8,000	14,653
FY 2014	15,000	15,000	25,347
FY 2015	0	0	7,000
Total, Design	47,000	47,000	47,000
Construction			
FY 2014	20,000[b]	20,000	6,000
FY 2015	25,000	25,000	20,000
FY 2016	42,000	42,000	35,000
FY 2017	43,000	43,000	35,000
FY 2018	32,900	32,900	31,000
FY 2019	0	0	21,000
FY 2020	0	0	12,000
FY 2021	0	0	2,900
Total, Construction	162,900	162,900	162,900
TEC			
FY 2012	24,000	24,000	0
FY 2013	8,000	8,000	14,653
FY 2014	35,000	35,000	31,347
FY 2015	25,000	25,000	27,000
FY 2016	42,000	42,000	35,000
FY 2017	43,000	43,000	35,000
FY 2018	32,900	32,900	31,000
FY 2019	0	0	21,000

[a] Congress approved a reprogramming that reduced the FY 2013 funding to $8,000,000 from the $22,685,000 that was originally appropriated.
[b] $20,000,000 is for long lead procurements for the superconducting magnet systems.

(dollars in thousands)

	Appropriations	Obligations	Costs
FY 2020	0	0	12,000
FY 2021	0	0	2,900
Total, TEC	209,900	209,900	209,900
Other Project Costs (OPC)			
OPC except D&D			
FY 2010	4,777	4,777	3,769
FY 2011	8,400	8,400	8,940
FY 2012	8,000	8,000	6,740
FY 2013	2,500	2,500	1,020
FY 2014	0	0	3,208
Total, OPC	23,677	23,677	23,677
Total Project Cost (TPC)			
FY 2010	4,777	4,777	3,769
FY 2011	8,400	8,400	8,940
FY 2012	32,000	32,000	6,740
FY 2013	10,500	10,500	15,673
FY 2014	35,000	35,000	34,555
FY 2015	25,000	25,000	27,000
FY 2016	42,000	42,000	35,000
FY 2017	43,000	43,000	35,000
FY 2018	32,900	32,900	31,000
FY 2019	0	0	21,000
FY 2020	0	0	12,000
FY 2021	0	0	2,900
Total, TPC	233,577[a]	233,577[a]	233,577[a]

[a] This project has not yet received CD-2 approval.

6. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design			
Design	40,000	40,000	N/A
Contingency	7,000	9,000	N/A
Total, Design	47,000	49,000	N/A
Construction			
Site Work	2,000	2,000	N/A
Construction	17,000	17,000	N/A
Equipment	99,000	99,000	N/A
Contingency	44,900	44,000	N/A
Total, Construction	162,900	162,000	N/A
Total, TEC	209,900	211,000	N/A
Contingency, TEC	51,900	53,000	N/A
Other Project Cost (OPC)			
OPC except D&D			
R&D	6,600	2,500	N/A
Conceptual Planning	4,350	4,350	N/A
Conceptual Design	12,727	12,727	N/A
Contingency	0	4,100	N/A
Total, OPC	23,677	23,677	N/A
Contingency, OPC	0	4,100	N/A
Total, TPC	233,577	234,677	N/A
Total, Contingency	51,900	57,100	N/A

7. Schedule of Appropriation Requests

(dollars in thousands)

Request Year		Prior Years	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	Total
FY 2011	TEC	5,000	30,000	0	0	0	0	0	0	35,000
	OPC	10,000	0	0	0	0	0	0	0	10,000
	TPC	15,000	30,000	0	0	0	0	0	0	45,000
FY 2012	TEC	0	24,000	12,500	0	0	0	0	0	36,500
	OPC	12,777	6,000	0	0	0	0	0	0	18,777
	TPC	12,777	30,000	12,500	0	0	0	0	0	55,277
FY 2013	TEC	0	24,000	20,000	0	0	0	0	0	44,000
	OPC	13,177	6,000	5,000	0	0	0	0	0	24,177
	TPC	13,177	30,000	25,000	0	0	0	0	0	68,177
FY 2014	TEC	0	24,000	24,147	35,000	32,000	44,000	45,000	23,000	223,000
	OPC	13,177	8,000	8,049	0	0	0	0	0	26,177
	TPC	13,177	32,000	32,196	35,000	32,000	44,000	45,000	23,000	249,177
FY 2013 Repro-gramming	TEC	0	24,000	8,000	35,000	32,000	44,000	45,000	23,000	211,000
	OPC	13,177	8,000	2,500	0	0	0	0	0	23,677
	TPC	13,177	32,000	10,500	35,000	32,000	44,000	45,000	23,000	234,677
FY 2015	TEC	0	24,000	8,000	35,000	25,000	42,000	43,000	32,900	209,900
	OPC	13,177	8,000	2,500	0	0	0	0	0	23,677
	TPC	13,177	32,000	10,500	35,000	25,000	42,000	43,000	32,900	233,577

8. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy	FY 2021
Expected Useful Life	10 years
Expected Future Start of D&D of this capital asset	FY 2031

Operations and maintenance of this experiment will become part of the existing Fermilab accelerator facility. Annual related funding estimates are for the incremental cost of five years of full operation, utilities, maintenance and repairs with the accelerator beam on. Five subsequent years are planned for further analysis of the data while the detector and beam line are maintained in a minimal maintenance state (with annual cost of approximately 3% of full operations) to preserve availability for future usage with much smaller annual cost.

(Related Funding Requirements)

	Annual Costs		Life Cycle Costs	
	Current Total Estimate	Previous Total Estimate	Current Total Estimate	Previous Total Estimate
Operations	3,100	3,100	16,000	16,000
Utilities	2,400	2,400	12,400	12,400
Maintenance & Repair	100	100	600	600
Recapitalization	0	0	0	0
Total	5,600	5,600	29,000	29,000

9. Required D&D Information

	Square Feet
Area of new construction	Approximately 25,000 SF
Area of existing facility(ies) being replaced and D&D'd by this project	0
Area of other D&D outside the project	0
Area of any additional D&D space to meet the the "one-for-one" requirement taken from the banked area.	Approximately 25,000 SF

The one-for-one replacement has been met through banked space. A waiver from the one-for-one requirement to eliminate excess space at Fermilab to offset the Mu2e project was approved by DOE Headquarters on November 12, 2009. The waiver identified and transferred to Fermilab 575,104 square feet of excess space to accommodate the new Mu2e facilities and other as yet unbuilt facilities from space that was banked at other DOE facilities.

10. Acquisition Approach

The acquisition approach is fully documented in the Acquisition Strategy approved as part of CD-1. This is a high-level summary of material from that document.

DOE has awarded the prime contract for the Mu2e project to the Fermi Research Alliance (FRA), the Fermilab Management and Operating (M&O) contractor, rather than have the DOE compete a contract for fabrication to a third party. FRA has a strong relationship with the high energy physics community and its leadership, including many Fermilab scientists and engineers. This arrangement will facilitate close cooperation and coordination between the Mu2e scientific collaboration and an experienced team of project leaders managed by FRA. FRA will have primary responsibility for oversight of all subcontracts required to execute the project. These subcontracts are expected to include the purchase of components from third party vendors as well as subcontracts with university groups to fabricate detector subsystems.

The largest procurements will be the magnet systems and the civil construction. The superconducting solenoid magnets are divided into three systems that could be procured independently but which must ultimately perform as a single integrated magnetic system. Two of the systems are similar to systems that have been successfully built in private industry, so the engineering design and fabrication for two of the solenoids may be subcontracted to third party vendors, if a planned study of industrial vendor capabilities confirms that the technical risks are acceptable. The third solenoid is relatively unique, and no good industrial analog exists. This solenoid will be designed and fabricated at Fermilab, though most of the parts will be procured from third party vendors.

There will be two major subcontracts for the civil construction for Mu2e. An architecture and engineering (A&E) contract will be placed on a firm-fixed-price basis for Preliminary (Title I) Design, and Final (Title II) Design with an option for construction (Title III) support. The general construction subcontract will be placed on a firm-fixed-price basis. It is expected that the design specifications will be sufficiently detailed to allow prospective constructors to formulate firm-fixed-price offers without excessive contingency and allowances.

All subcontracts will be competitively bid and awarded based on best value to the government. Chicago Office provides contract oversight for FRA's plans and performance. Project performance metrics for FRA are included in the M&O contractor's annual performance evaluation and measurement plan.

Nuclear Physics

Overview

One of the enduring mysteries of the universe is the nature of matter—what are its basic constituents and how do they interact to form the properties we observe? The largest contribution by far to the mass of the matter we are familiar with comes from the nuclei of atoms. The mission of the Nuclear Physics (NP) program is to discover, explore, and understand all forms of nuclear matter. Although the fundamental particles that compose nuclear matter—quarks and gluons—are themselves relatively well understood, exactly how they interact and combine to form the different types of matter observed in the universe today and during its evolution remains largely unknown.

The quest to understand the properties of different forms of nuclear matter requires both theoretical and experimental efforts. Theoretical approaches are based on a description of the interactions of quarks and gluons described by a theory known as Quantum Chromodynamics (QCD). This theory is studied by scientists using today's most advanced computers. Other theoretical research that models the forces between nucleons seeks to understand and predict the structure of nuclear matter. In experimental research, scientists accumulate experimental data about the behavior of quarks and gluons as well as their composite protons, neutrons, and nuclei in a variety of settings. Most experiments today in nuclear physics use large particle accelerators that collide bits of matter together at nearly the speed of light, producing short-lived forms of matter for investigation. Comparing experimental observations and theoretical predictions tests the limits of our understanding of nuclear matter and suggests new directions for both experimental and theoretical research. Nuclear physics seeks to understand matter a wide variety of manifestations—not just the familiar forms we see around us, but also exotic forms such as that which existed in the first moments after the Big Bang and those that exist today inside neutron stars—and to understand why matter takes on the specific forms now observed in nature.

Nuclear physics addresses three broad yet tightly interrelated scientific thrusts: Quantum Chromodynamics, Nuclei and Nuclear Astrophysics, and Fundamental Symmetries of neutrons and nuclei. Quantum Chromodynamics seeks to develop a complete understanding of how the fundamental particles that compose nuclear matter, the quarks and gluons, assemble themselves into composite nuclear particles such as protons and neutrons, how nuclear forces arise between these composite particles that lead to nuclei, and what forms of bulk strongly interacting matter can exist in nature, such as the quark-gluon plasma. Nuclei and Nuclear Astrophysics seeks to understand how protons and neutrons combine to form atomic nuclei, including some now being observed for the first time, and how these nuclei have arisen during the 13.8 billion years since the birth of the cosmos. Fundamental Symmetries seeks to develop a better understanding of fundamental interactions by studying the properties of neutrons and targeted, single focus experiments using nuclei to study whether the neutrino is its own anti-particle. Neutrinos are very light, nearly undetectable fundamental particles produced during interactions involving the weak force, through which they were first (indirectly) observed in nuclear beta decay experiments.

At the heart of the NP program are groups of highly trained scientists who conceive, plan, execute, and interpret transformative experiments. NP supports university and national laboratory scientists and a variety of international collaborations. It provides more than 90 percent of the nuclear science research funding in the U.S. with an average of 85 Ph.D. degrees granted annually to students for research supported by the program. NP research is guided by DOE's mission and priorities and helps develop the core expertise needed to achieve the goals of the NP program. National laboratory scientists work and collaborate with academic scientists and other national laboratory experimental and theoretical researchers to collect and analyze data and to construct, support, and maintain the detectors and facilities used in experiments. The national laboratories also provide state-of-the-art resources for targeted detector and accelerator R&D for future upgrades and new facilities. This research develops knowledge, technologies, and scientists to design and build next-generation NP accelerator facilities. It is also of relevance to machines being developed by other domestic and international programs.

The complementary user facilities and their associated equipment necessary to advance the U.S. nuclear science program supported by NP are large and complex, and account for about half of NP's budget. Three national scientific user facilities are currently supported, each with unique capabilities: the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory (BNL); the Continuous Electron Beam Accelerator Facility (CEBAF) at Thomas Jefferson National Accelerator Facility (TJNAF); and the Argonne Tandem Linac Accelerator System (ATLAS) at Argonne National Laboratory (ANL). These facilities provide particle beams for an international user community of more than 3,000 research scientists. Approximately 38 percent of these researchers are from institutions outside of the U.S. and provide very significant benefits to leverage the U.S. program through contributed capital, human capital, experimental equipment, and intellectual contributions. Other SC programs, DOE offices (National Nuclear Security Administration [NNSA] and Nuclear Energy), Federal agencies (National Science Foundation [NSF], National Aeronautics and Space Administration [NASA], and Department of Defense), and industries also use NP user facilities to carry out their research programs. In addition, a major energy upgrade at CEBAF is underway and construction of the Facility for Rare Isotope Beams (FRIB) has begun at Michigan State University (MSU). Disposition activities continue for the Holifield Radioactive Ion Beam Facility (HRIBF) at ORNL.

Involving students in the development and construction of NP facilities and advanced instrumentation, along with the development of accelerator technology and computational techniques, supports workforce development. In addition to significant advances in discovery science, these facilities and techniques provide collateral benefits such as the creation of new technologies with broad-based applications in industry and society. The High Energy Physics program supports long-term and generic accelerator R&D that is applicable to a variety of basic and applied missions, while NP supports short- or mid-term accelerator R&D that is specific to the programmatic needs of current or planned facilities. In the process, however, technological advances developed by NP are also often relevant to other applications. For example, superconducting radio frequency (SRF) particle acceleration developed for NP programmatic missions has provided technological advances for a broad range of applications including materials research, cancer therapy, food safety, bio-threat mitigation, waste treatment, and commercial fabrication. The Office of Science programs coordinate closely on the different types of accelerator R&D activities to exploit synergies.

Highlights of the FY 2015 Budget Request

The FY 2015 requested increase of $24,435,000 over FY 2014 is driven by a $35,000,000 increase for construction and final technical design of the FRIB project, which will provide intense beams of rare isotopes for a wide variety of studies in nuclear structure, nuclear astrophysics and fundamental symmetries. Funding for university and laboratory research in Nuclear Physics will allow significant advances in nuclear structure, nuclear astrophysics, the study of matter at extreme conditions, hadronic physics, fundamental properties of the neutron and neutrinoless double beta decay. In FY 2015, NP will support ongoing core research activities at approximately the FY 2014 level. Operations of the RHIC facility are maintained, and research focuses on characterizing the perfect quark-gluon liquid discovered in collisions of relativistic heavy nuclei through research on particle flow and jet energy loss. Operations of the ATLAS facility are optimized, exploiting the new capabilities of the Californium Rare Ion Breeder Upgrade (CARIBU) and completing the campaign with the GRETINA gamma ray spectrometer. Beam development and commissioning activities ramp up at CEBAF as the 12 GeV CEBAF Upgrade project approaches completion and construction support transitions to operations funding. Support for the Isotope Development and Production for Research and Applications subprogram maintains mission readiness for the production of radioisotopes that are in short supply for research and a wide array of applications. Research investments in this subprogram aim to establish the full-scale production capability of the promising alpha-emitter, Actinium-225, to enable clinical trials for cancer therapy.

Nuclear Physics
Funding ($K)

	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Medium Energy Nuclear Physics					
Research	35,810	36,864	36,864	36,007	-857
Operations	78,123	94,493	94,493	96,050	+1,557
SBIR/STTR and Other	1,784	17,338	17,338	17,835	+497
Total, Medium Energy Nuclear Physics	**115,717**	**148,695**	**148,695**	**149,892**	**+1,197**
Heavy Ion Nuclear Physics					
Research	36,208	34,621	34,621	33,894	-727
Operations	157,021	165,072	165,072	165,072	0
Total, Heavy Ion Nuclear Physics	**193,229**	**199,693**	**199,693**	**198,966**	**-727**
Low Energy Nuclear Physics					
Research	51,118	49,180	49,180	48,450	-730
Operations	27,072	26,524	26,524	26,819	+295
Facility for Rare Isotope Beams[a]	22,000	0	0	0	0
Total, Low Energy Nuclear Physics	**100,190**	**75,704**	**75,704**	**75,269**	**-435**
Nuclear Theory					
Theory Research	32,867	38,115	38,115	35,719	-2,396
Nuclear Data Activities	6,190	7,027	7,027	7,377	+350
Total, Nuclear Theory	**39,057**	**45,142**	**45,142**	**43,096**	**-2,046**
Isotope Development and Production for Research and Applications					
Research	4,228	4,562	4,562	4,562	0
Operations	14,255	14,842	14,842	15,288	+446
Total, Isotopes	**18,483**	**19,404**	**19,404**	**19,850**	**+446**
Subtotal, Nuclear Physics	**466,676**	**488,638**	**488,638**	**487,073**	**-1,565**

[a] Funding in FY 2014 and FY 2015 for the Facility for Rare Isotope Beams (FRIB) has been moved to Construction according to the FY 2014 enacted appropriation, which established FRIB as a control point.

	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Construction					
06-SC-01, 12 GeV CEBAF Upgrade, TJNAF	40,572	25,500	25,500	16,500	-9,000
14-SC-50, Facility for Rare Isotope Beams	0[b]	55,000	55,000	90,000	+35,000
Total, Construction	**40,572**	**80,500**	**80,500**	**106,500**	**+26,000**
Total, Nuclear Physics	**507,248**	**569,138**	**569,138**	**593,573**	**+24,435**

SBIR/STTR:

- FY 2013 transferred: SBIR: $11,163,887 ; STTR: $1,447,171
- FY 2014 projected: SBIR: $12,557,000 ; STTR: $1,794,000
- FY 2015 Request: SBIR: $13,024,000 ; STTR: $1,796,000

[b] FY 2013 funding for the Facility for Rare Isotope Beams is included in the Low Energy Nuclear Physics subprogram.

Nuclear Physics
Explanation of Major Changes ($K)

	FY 2015 vs. FY 2014 Enacted
Medium Energy Nuclear Physics: Key staff from the 12 GeV CEBAF Upgrade project continue to transition back to CEBAF operations funding to support commissioning and operations of the facility. Partially offsetting that increase is a decrease in funding for university research relative to FY 2014.	**+1,197**
Heavy Ion Nuclear Physics: Funding for university research decreases relative to FY 2014.	**-727**
Low Energy Nuclear Physics: Funding for university research decreases relative to FY 2014.	**-435**
Nuclear Theory: Funding for university research decreases relative to FY 2014. Partially offsetting the decrease is an increase in support for the National Nuclear Data program to retain key personnel.	**-2,046**
Isotope Development and Production for Research and Applications: Funding is provided to maintain mission readiness of the isotope production and processing facilities at a constant level of effort at Brookhaven, Oak Ridge, and Los Alamos National Laboratories.	**+446**
Construction: FY 2015 construction funding increases for the Facility for Rare Isotope Beams (+$35,000,000) and decreases for the 12 GeV CEBAF Upgrade project (-$9,000,000) according to the approved baseline profiles for both projects.	**+26,000**
Total, Nuclear Physics	**+24,435**

Basic and Applied R&D Coordination

Within the NP mission, unique opportunities exist and are pursued for R&D integration and coordination with other DOE Program Offices, Federal Agencies and non-Federal entities. For example, researchers from High Energy Physics, Nuclear Physics, and Advanced Scientific Computing Research (ASCR) coordinate and leverage forefront computing resources and technical expertise through the Lattice Quantum Chromodynamics (LQCD) and SciDAC projects to determine the properties of as-yet unobserved exotic particles predicted by the theory of Quantum Chromodynamics, advance progress towards a model of nuclear structure with predictive capability, and dramatically improve modeling of neutrino interactions during core collapse supernovae. The National Nuclear Data Center provides evaluated cross-section and decay data relevant to reactor design (e.g., of interest to Nuclear Energy [NE] and Fusion Energy Sciences [FES]), materials under extreme conditions (Basic Energy Sciences and FES), and nuclear forensics (National Nuclear Security Administration [NNSA], Department of Homeland Security [DHS], and Federal Bureau of Investigations [FBI]). NP has supported competitive targeted awards in Applications of Nuclear Science and Technology (ANS&T) of relevance to the development of advanced fuel cycles for next generation nuclear reactors (NE); advanced cost-effective accelerator technology and particle detection techniques for medical diagnostics and treatment (National Institutes of Health, High Energy Physics); and research in developing neutron, gamma, and particle beam sources with applications in cargo screening and nuclear forensics (NNSA, DHS, and FBI

R&D coordination and integration are hallmarks of the NP Isotope Development and Production for Research and Applications (Isotope) subprogram which produces commercial and research isotopes in short supply and critical for basic research and applications. It also supports research for the development of new or improved production and separation techniques of stable and radioactive isotopes. NP has taken significant steps in aligning the Federal, industrial, and research stakeholders of the Isotope Program and improving communication between the various communities. To ascertain current and future demands of the research and applied communities, NP organizes working groups, workshops, symposia, and discussions with a suite of Federal agencies and community and industrial stakeholders on a continuous basis; works collaboratively with other DOE Offices (NNSA and NE) to help ensure adequate supplies of isotopes needed for the nuclear power industry as well as for deep space exploration (NASA). The Isotope Program conducts annual Federal workshops to identify isotope demand and supply across a broad range of Federal agencies in support of research and applications within their areas of responsibility.

Program Accomplishments

Forecasting Neutron Star Cooling. Recent discoveries in x-ray astronomy and advances in theory have shown that neutron stars are unique laboratories to study matter at extreme density. A significantly improved model of the nuclear processes determining the properties of the neutron star crust now incorporates the solid and superfluid phases expected for extremely dense nuclear matter. Improved theory, modeling, and observations have led to new restrictions on key parameters, resulting in new insights and predictions for the cooling of a neutron star after intense accretion of matter from a companion star. Predictions for cooling can now be made more reliably, increasing the significance of theoretical interpretations of neutron star behavior and advancing knowledge of exotic states of dense nuclear matter.

Understanding the nearly perfect quark-gluon liquid. New experiments characterize the nearly perfect quark-gluon liquid discovered at RHIC. Recent experiments at the LHC have now confirmed RHIC's discovery that this matter behaves more as a liquid than a gas as originally thought. Comparison of key measurements at the two facilities concerning the properties of this quark-gluon liquid is critical to gain a detailed understanding of this form of matter that existed only a few millionths of a second after the birth of the universe. The results indicate that while the temperature of the matter formed at the LHC is higher than at RHIC, the matter formed at RHIC is a more perfect liquid with less resistance to flow of particles. This revelation is forging new experimental and theoretical insights into the fundamental nature of extreme states of dense nuclear matter.

How much of the Proton's Spin is carried by Gluons? New evidence from RHIC. How the spin of the proton is distributed among the quarks, antiquarks, and gluons confined inside the proton remains a fascinating open question. Although the fraction of the proton's spin carried by light quarks has been reasonably well established (about 30%), the fraction carried by gluons remains poorly understood. RHIC, the world's only high energy polarized-proton collider, is ideally suited to investigate the origin of the proton's spin. Preliminary new results indicate that gluons probably carry approximately 20% of this spin, the first indication that a large fraction of the proton's spin is carried by gluons. Data taken in 2013 at higher proton-proton collision energy of 510 GeV will be vital to further constrain the gluons' fraction of the proton's spin. The origin of the remaining 50% of the proton's spin remains to be identified, and may indicate a sizeable contribution from orbital motion of quarks and gluons inside the proton.

The Q-weak experiment at TJNAF—Determination of the Weak Charge of the Proton. The challenging "Q-weak" experiment, performed at Thomas Jefferson National Accelerator Facility, tests our present understanding of the Standard Model of electroweak interactions, and searches for evidence of new forces or particles. The experimental technique is to conduct a precise search for small effects in electron-proton scattering which indicate the violation of a fundamental symmetry of nature called parity. The degree to which parity is violated is related to a theoretical quantity called the weak charge of the proton, or Q-weak. This quantity is quite sensitive to the effects of new particles or interactions that are not described by the Standard Model of particle physics, and has the potential to confirm the accuracy of our understanding of the existence of particles and forces or point to yet undiscovered particles and forces. Results recently indicate that there is no evidence for new particles or interactions in electron-proton scattering up to the mass scale of up to 1.1 TeV, about 9 times the mass of the heaviest elementary particle known, the Higgs boson.

Mass Measurements on the r-Process Path: Results from CARIBU. Most of the light elements are produced in the cores of stars by fusion reactions. Understanding the elemental abundances resulting from supernovae requires developing models with a large number of physics inputs, such as the masses of some of the isotopes. Although stars create these isotopes readily in supernovae, producing them in the laboratory for astrophysics research is very challenging. At Argonne National Laboratory, the Californium Rare Ion Breeder Upgrade (CARIBU) now provides some isotopes of interest by capturing fragments from the fission of Californium for research and reacceleration. A nucleus of particular interest is tin-132, where the closure of two shells containing protons and neutrons results in an unusually high level of stability against nuclear decay, creating a bottleneck (waiting point) that slows down progression of r-process to heavier nuclei. First-ever simulations that incorporate information from new mass measurements at CARIBU indicate there is a significant increase in waiting time for the elements tin and antimony compared to calculations with commonly used mass models.

Long-standing question about how protons and neutrons interact resolved. A precise prediction of quantum chromodynamics (QCD) theory is a property of the proton called g_P, which accounts for the interactions of protons and neutrons via the weak force. For forty years, the measurement of this important quantity was elusive, owing to ambiguities in the underlying atomic physics needed to interpret experimental data. Two recent experiments, led by University of Washington Center for Experimental Nuclear Physics and Astrophysics (CENPA) researchers, completed part-per-million scale precision measurements of the positive muon lifetime and the negative muon lifetime. The difference in the two lifetimes leads directly to a precise determination of g_P. This unambiguous result, which avoids the experimental uncertainties in previous measurements, is in excellent agreement with theory and resolves a long-standing question about the value of this key parameter of QCD.

Nuclear Physics
Medium Energy Nuclear Physics

Description

The Medium Energy Nuclear Physics subprogram focuses primarily on experimental tests of the theory of the strong interaction, known as Quantum Chromodynamics (QCD). According to QCD, all observed nuclear particles, collectively known as hadrons, arise from the strong interaction of quarks, antiquarks, and gluons. The protons and neutrons inside nuclei are the best known examples of hadrons. QCD, although difficult to solve, predicts what hadrons exist in nature, and how they interact and decay. Specific questions addressed within this subprogram include:

- What is the internal landscape of the protons and neutrons (collectively known as nucleons)?
- What does QCD predict for the properties of strongly interacting matter?
- What governs the transition of quarks and gluons into pions (hadronic subatomic particle) and nucleons?
- What is the role of gluons and gluon self-interactions in nucleons and nuclei?

Various experimental approaches are used to determine the distribution of up, down, and strange quarks, their antiquarks, and gluons within protons and neutrons, as well as clarifying the role of gluons in confining the quarks and antiquarks within hadrons. Scattering experiments are used to clarify the effects of the quark and gluon spins within nucleons, and the effect of the nuclear environment on the quarks and gluons. The subprogram also supports experimental searches for higher-mass "excited state" hadrons predicted by QCD, as well as studies of their various production mechanisms and decay properties.

Medium Energy Nuclear Physics supports both research and operations of the subprogram's primary research facility, CEBAF at TJNAF, as well as the RHIC spin physics research that is carried out using RHIC at BNL. CEBAF provides high quality beams of polarized electrons that allow scientists to extract information on the quark and gluon structure of protons and neutrons from measurements of how the electrons scatter when they collide with nuclei. CEBAF also uses polarized electrons to make precision measurements to search for processes that violate a fundamental symmetry of nature, called parity, in order to search for physics beyond what is currently described by the Standard Model. These capabilities are unique in the world. The increase in beam energy provided by the 12 GeV CEBAF Upgrade opens up exciting new scientific opportunities, and will secure continued U.S. world leadership in this area of physics. Research at RHIC, which provides colliding beams of spin-polarized protons, a capability unique to RHIC, seeks to understand the origin of the spin of the proton, another important challenge in QCD. Research support for both facilities includes laboratory and university personnel needed to implement and execute experiments and to conduct the data analysis necessary to extract scientific results. Compelling special focus experiments that require different capabilities are also supported at the High Intensity Gamma Source (HIGS) at Triangle Universities Nuclear Laboratory, the Fermi National Accelerator Laboratory (Fermilab), and in Europe. Efforts are supported at the Research and Engineering Center of the Massachusetts Institute of Technology (MIT), which has specialized infrastructure used to develop and fabricate advanced instrumentation and accelerator equipment.

The SBIR/STTR and Other category within this subprogram includes all of the mandated SBIR/STTR funding for the NP program, as well as funding to meet other NP obligations, such as the annual Lawrence Awards and Fermi Awards for honorees selected by DOE for outstanding contributions to science.

<u>Research</u>

Research groups at TJNAF, BNL, ANL, LANL, and LBNL, and approximately 160 scientists and 125 graduate students at 32 universities carry out research programs and conduct experiments at CEBAF, RHIC, and elsewhere, and participate in the development and fabrication of advanced instrumentation, including state-of-the-art detectors that also have applications in areas such as medical imaging instrumentation and homeland security. TJNAF staff research efforts include developing experiments, acquiring data, and performing data analysis at the three existing CEBAF experimental Halls A, B, and C. A fourth scientific research group at TJNAF is being established to exploit the experimental capabilities of the new Hall D, being constructed as part of the 12 GeV CEBAF Upgrade project. Scientists conduct research to identify and develop the opportunities and goals for next generation facilities. An active visiting scientist program at TJNAF and bridge positions with regional universities are also supported as a cost-effective approach to augmenting scientific expertise at the laboratory and boosting research experience opportunities.

ANL scientists continue targeted experiments at TJNAF and are leading an experiment at Fermilab to determine the antiquark contribution to the structure of the proton. ANL scientists are also developing a technique for making precise measurements of the electric dipole moments of laser-trapped atoms that will set limits on QCD parameters and contribute to the search for possible explanations of the excess of matter over antimatter in the universe. Research groups at BNL, LBNL, ANL, and LANL play leading roles in determining the spin structure of the proton through the development and fabrication of advanced instrumentation for RHIC, as well as contributing to data acquisition and analysis efforts. At LANL, this effort is ramped down in FY 2015 as resources there are focused on higher priority efforts. Participation of LANL scientists in the MiniBooNE experiment at Fermilab, which has shown an intriguing discrepancy between anti-neutrino and neutrino data and may unveil new physics beyond the Standard Model, are also concluded in FY 2015. Researchers at MIT and at TJNAF are developing high current, polarized electron sources for next generation NP facilities.

Accelerator R&D research proposals from universities and laboratories specific to improving operations of current NP facilities or developing new NP facilities are evaluated by peer review through a single competition for funding under the Medium Energy and Heavy Ion subprograms.

Operations

CEBAF's polarized electron beam capabilities are used to study the contributions of quarks and gluons to the properties of hadrons by a user community with a strong international component. Accelerator Operations support is provided for the accelerator physicists at TJNAF that operate CEBAF as well as for maintenance, power costs, capital infrastructure investments, and accelerator improvements. Modest investments in high priority accelerator improvement projects are aimed at increasing the productivity, cost-effectiveness, and reliability of the facility. Support is provided for the most important efforts in developing advances in superconducting radiofrequency (SRF) technology relevant to improving operations of the existing machine. The core competency in SRF technology plays a crucial role in many DOE projects and facilities outside of nuclear physics and has broad applications in medicine and homeland security. For example, SRF research and development at TJNAF has led to improved land-mine detection techniques and carbon nanotube and nano-structure manufacturing techniques for constructing super-lightweight composites such as aircraft fuselages. TJNAF also has a core competency in cryogenics and has developed award-winning techniques that have led to more cost-effective operations at TJNAF and several other Office of Science facilities. Accelerator capital equipment investments are targeted toward instrumentation needed to support the laboratory's core competencies in SRF and cryogenics. TJNAF accelerator physicists help train the next generation of accelerator physicists, enabled in part by a close partnership with the NP-supported Center for Accelerator Science at Old Dominion University. Experimental Support is provided for the scientific and technical staff as well as for materials and supplies for integration, assembly, modification, and disassembly of the large and complex CEBAF experiments. Modest capital equipment investments for experimental support at TJNAF provide scientific instrumentation for the major experiments, including data acquisition computing and supporting infrastructure.

Medium Energy Nuclear Physics

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Research		
Efforts are focused on preparations for the new 12 GeV experimental program at TJNAF such as the implementation of instrumentation and development of the Hall D experimental group, as well as continued analysis of RHIC polarized proton beam data and 6 GeV experimental data, such as physics beyond the Standard Model of electroweak forces (Q-weak), the role of strange quarks in hadrons (HAPPEx), neutron skins in nuclei (PReX), and excited baryons (HDIce). Support for short and mid-term accelerator R&D continues. University research is increased in FY 2014 to ease the transition to fully funding research awards of $1M or less.	Efforts continue on preparations for the 12 GeV experimental program at TJNAF such as the implementation of instrumentation and development of the Hall D experimental group, as well as continued analysis of 6 GeV experimental data and RHIC polarized proton beam data. Support for short and mid-term accelerator R&D continues. ANL scientists will complete the measurement of antiquark structure of the nucleon and nucleus with the E906 Drell-Yan experiment.	Funding for university research decreases relative to FY 2014. All other research is held flat with FY 2014.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Operations		
FY 2014 funding supports transitioning 40 FTEs from the 12 GeV CEBAF Upgrade construction project back to base operations support in order to start commissioning and operating the upgraded CEBAF machine and equipment. CEBAF is being restarted after an 18-month shutdown for installation of 12 GeV CEBAF Upgrade project components. Support increases for power and cryogens to begin pre-operations, beam study activities, and commissioning. 12 GeV CEBAF Upgrade Other Project Costs are supported in accordance with the revised baseline project profile approved in September 2013, and are essential for demonstration of project deliverables. Implementation of instrumentation for the planned scientific research program continues.	FY 2015 funding supports the transition of an additional 45 FTEs from the 12 GeV CEBAF Upgrade construction project back to base operations support. In order to support this critical transition, accelerator and instrumentation investments are constrained, and beam development is limited to the highest priority activities associated with completion of the 12 GeV CEBAF Upgrade project. Funding is provided for Other Project Costs (within project TPC) as planned as part of the 12 GeV CEBAF Upgrade project profile. The major milestone in FY 2015 will be establishing first beams to Hall D for commissioning activities.	An increase of approximately $7 million is needed to support the 45 operations staff FTEs transitioning from the 12 GeV Upgrade project back to the base operations budget. This increase for the high priority transition of staff has been partially offset by redirecting funds from other activities, such as facility experimental equipment, accelerator improvement projects, accelerator R&D, laboratory GPP, materials and supplies, and beam development operations.
SBIR/STTR and Other		
Support is provided for NP's required contribution to the SBIR/STTR programs, as well as other DOE and Office of Science obligations, such as the annual Fermi and Lawrence awards.	Support is provided for NP's required contribution to the SBIR/STTR programs, as well as other DOE and Office of Science obligations.	The SBIR/STTR funding set-aside of 3.2% in FY 2014 increases to 3.3% in FY 2015.

Nuclear Physics
Heavy Ion Nuclear Physics

Description

The Heavy Ion Nuclear Physics subprogram focuses on studies of nuclear matter at extremely high densities and temperatures, directed primarily at answering the overarching questions within the Quantum Chromodynamics (QCD) scientific thrust, including:

- What are the phases of strongly interacting matter, and what roles do they play in the cosmos?
- What governs the transition of quarks and gluons into pions and nucleons?
- What determines the key features of QCD and their relation to the nature of gravity and space-time?

At the Relativistic Heavy Ion Collider (RHIC) facility, scientists continue to pioneer the study of condensed quark-gluon matter at the extreme temperatures characteristic of the infant universe. The intellectual goal is to explore and understand unique manifestations of QCD in this many-body environment and their influence on the universe's evolution. Complementary research capability is also provided at the Large Hadron Collider (LHC) at CERN. In the debris of collisions at RHIC and at the LHC, researchers have seen signs of the same quark-gluon plasma that is believed to have existed shortly after the Big Bang. With careful measurements, scientists are accumulating data that offer insights into the processes early in the creation of the universe, and how protons, neutrons, and other bits of normal matter developed from that plasma. Important avenues of investigation are directed at learning more about the physical characteristics of the quark-gluon plasma including exploring the energy loss mechanism for quarks and gluons traversing the plasma, determining the speed of sound in the plasma and locating the critical point for the transition between the plasma and normal matter.

The RHIC facility places heavy ion research at the frontier of nuclear physics. RHIC serves two large-scale international experiments called PHENIX and STAR. Operation of RHIC in FY 2015 will continue to take advantage of the increase in the heavy ion beam collision rate using the stochastic cooling systems completed in FY 2013 and the Electron Beam Ion Source (EBIS). New and ongoing detector upgrades coupled with the enhanced collision rate will contribute further scientific results and understanding. The RHIC facility is uniquely flexible, providing a full range of colliding nuclei at variable energies spanning the transition to the new state of matter discovered at RHIC. Short and mid-term accelerator R&D is conducted at RHIC in a number of areas including the cooling of high-energy hadron beams based on a new concept called Coherent Electron Cooling; high intensity polarized electron sources; and high-energy, high-current energy recovery linear (ERL) accelerators. The RHIC facility is used by about 1,200 DOE, NSF, and foreign agency-supported researchers annually.

Collaboration in the heavy ion program at the LHC at CERN provides U.S. researchers the opportunity to investigate states of matter under substantially different initial conditions than those provided by RHIC, providing complementary information regarding the matter that existed during the infant universe. Data collected by the ALICE, CMS, and ATLAS detectors confirm that the same quark-gluon plasma is seen at the higher energy. In addition to playing a lead role in the fabrication and operation of a large electromagnetic calorimeter detector installed in FY 2010 in the ALICE experiment, U.S. researchers are making important scientific contributions to the emerging results from all three LHC experiments.

Research

Heavy ion research groups at BNL, LBNL, LANL, ORNL, and LLNL, and about 120 scientists and 100 graduate students at 28 universities are supported to analyze data from RHIC and participate in a modest program at the LHC.

The university and national laboratory research groups provide the scientific personnel and graduate students needed for running the RHIC and LHC heavy ion experiments; analyzing data; publishing results; conducting R&D of next-generation detectors; planning for future experiments; and designing, fabricating, and operating the RHIC and LHC heavy ion detectors. BNL also provides project management oversight for the fabrication of the STAR Heavy Flavor Tracker (HFT) MIE. BNL and LBNL provide computing infrastructure for petabyte-scale data analysis and state-of-the-art facilities for detector and instrument development. At LBNL, a large scale computational system, the Parallel Distributed Systems Facility (PDSF), is a major resource used for the analysis of RHIC and LHC data in alliance with the National Energy Research Scientific Computing Center (NERSC), which is supported by the SC's Advanced Scientific Computing Research program. LLNL computing resources are also used for LHC data analysis.

Accelerator R&D research proposals for short and mid-term accelerator R&D from universities and laboratories specific to improving operations of current NP facilities or developing new NP facilities are evaluated by peer review through a single competition for funding under the Heavy Ion and Medium Energy subprograms.

Operations

Support is provided for the operations, power costs, capital infrastructure investments, and accelerator improvement projects of the RHIC accelerator complex at BNL. This includes the Electron Beam Ion Source (EBIS), Booster, and the Alternating Gradient Synchrotron (AGS) accelerators that together serve as the injector for RHIC. RHIC operations allow for parallel and cost-effective operations of the Brookhaven Linac Isotope Producer Facility (BLIP), supported by NP for the production of research and commercial isotopes critically needed by the Nation, and of the NASA Space Radiation Laboratory Program for the study of space radiation effects applicable to human space flight. Through operations of the RHIC complex, important core competencies are nurtured in accelerator physics techniques to improve RHIC performance and support the NP mission. These core competencies provide collateral benefits to applications in industry, medicine, homeland security, and other scientific projects outside of NP. RHIC accelerator physicists are leading the effort to address technical feasibility issues of relevance to a possible next-generation collider for the NP program, including beam cooling techniques and energy recovery linacs. These physicists also play an important role in the training of next generation accelerator physicists, with support of graduate students and post-doctoral associates.

Heavy Ion Nuclear Physics

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Research		
Researchers are participating in the collection and analysis of data from RHIC to investigate the interaction of heavy quarks with the quark gluon plasma, and in the conduct of R&D for innovative detector designs and planning for future experiments. NP provides scientific leadership to the international heavy ion experiment ALICE, and the heavy ion research components of the CMS and ATLAS experiments; the LHC runs in heavy ion mode for 1 month per year, after HEP running is concluded. NP also provides related funding to the LHC for U.S. commitments for management and operating costs of the heavy ion program. The fabrication of the STAR Heavy Flavor Tracker detector, an experiment to take advantage of RHIC's luminosity, is on track for early completion and utilization in RHIC's Run 14. Mid- and short-term accelerator R&D is also supported. University research is increased in FY 2014 to ease the transition to fully funding research awards of $1M or less.	Researchers will continue to participate in the collection and analysis of data from RHIC with newly completed scientific instrumentation to study collisions with a range of light and heavy nuclei to better understand the initial conditions in heavy ion collisions, and in the conduct of limited R&D for innovative detector designs and planning for future experiments. NP provides scientific leadership to the international ALICE, CMS, and ATLAS experiments, as well as providing the required funding to the LHC for U.S. commitments for management and operating costs. Mid- and short-term accelerator R&D relevant to NP programmatic needs is also supported. The STAR Heavy Flavor Detector major item of equipment is completed.	Funding for university research decreases relative to FY 2014. All other research is held flat with FY 2014.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Operations		
RHIC operations will provide for 2,770 beam hours (approximately 22 weeks and 68 percent utilization) in support of the planned RHIC research program. Efforts continue to increase the heavy ion and proton-proton beam luminosity for enhanced scientific productivity. Newly completed electron lenses should improve polarized proton luminosity. A 56 MHZ superconducting storage cavity is being installed at RHIC to increase the RHIC luminosity by about 30%.	RHIC operations will provide for 2,770 beam hours (approximately 22 weeks and 68 percent utilization) in support of the planned RHIC research program that takes advantage of dramatic improvements in collider performance and versatility made possible by recent RHIC upgrades. Funds for experimental equipment, accelerator R&D, and materials and supplies are reduced in FY 2015 in order to optimize running levels.	RHIC Operations are held flat with FY 2014.

Nuclear Physics
Low Energy Nuclear Physics

Description

The Low Energy Nuclear Physics subprogram focuses on answering the overarching questions associated with Nuclei and Nuclear Astrophysics and with Fundamental Symmetries, two areas identified as scientific priorities in the 2007 Long Range Plan for Nuclear Science.[a]

Questions associated with Nuclei and Nuclear Astrophysics include:

- What is the nature of the nuclear force that binds protons and neutrons into stable nuclei and rare isotopes?
- What is the origin of simple patterns in complex nuclei?
- What is the nature of neutron stars and dense nuclear matter?
- What is the origin of the elements in the cosmos?
- What are the nuclear reactions that drive stars and stellar explosions?

This subprogram addresses these questions by supporting research to develop a comprehensive description of nuclei using beams of stable and rare isotopes to yield new insights and reveal new nuclear phenomena. The subprogram also measures the cross sections of the nuclear reactions that power stars and lead to spectacular stellar explosions, which are responsible for the synthesis of the elements.

Questions addressed in Fundamental Symmetries of neutrons and nuclei (which uses neutrinos and neutrons as primary probes) include:

- What experimental approach for a next generation, ton-scale neutrino-less double beta day detector is capable of achieving the sensitivity necessary to determine if the neutrino is it own anti-particle?
- Is there evidence from the electric-dipole moments of atomic nuclei and the neutron that our current understanding of the fundamental laws governing nuclear physics is incomplete?
- Does evidence for parity violation in electron scattering and possible lepton number violation in the decay of nuclei indicate forces present at the dawn of the universe that disappeared from view as the universe evolved?

This subprogram addresses these questions through precision measurements primarily with neut rons and neutrinos. Beams of cold and ultracold neutrons are used to study fundamental properties of neutrons. Precision studies to observe or set a limit on violation of time-reversal invariance—the principle that the physical laws should not change if the direction of time is reversed—in nucleonic, nuclear, and atomic systems investigate fundamental questions in nuclear physics, astrophysics, and cosmology.

The ATLAS national scientific user facility has been pivotal in making progress in Nuclear Structure and Nuclear Astrophysics, serving a combined international community of approximately 400 scientists. ATLAS provides high-quality beams of all the stable elements up to uranium as well as selected beams of short-lived nuclei for experimental studies of nuclear properties under extreme conditions and reactions of interest to nuclear astrophysics.

HRIBF ceased operations in 2012. Disposition activities of this facility continue in FY 2015. Analysis of data from HRIBF on exotic nuclei that do not normally exist in nature and reactions of interest to nuclear astrophysics and isotope production is continuing.

NP supports the LBNL 88-Inch Cyclotron jointly with the National Reconnaissance Office (NRO) and the U.S. Air Force (USAF). Accelerator operations are supported at two university Centers of Excellence with specific goals and unique physics

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[a] http://science.energy.gov/~/media/np/nsac/pdf/docs/nuclear_science_low_res.pdf

programs: the Cyclotron Institute at Texas A&M University (TAMU) and accelerator facilities at the Triangle Universities Nuclear Laboratory (TUNL) at Duke University. A third university center, the Center for Experimental Nuclear Physics and Astrophysics (CENPA) at the University of Washington, provides unique expertise and capabilities for instrumentation development.

Progress in nuclear structure and nuclear astrophysics depends increasingly upon the availability of rare isotope beams. While ATLAS has some capabilities for these studies, one of the highest priorities for the NP program is support for the construction of a facility with world-leading capabilities for short-lived radioactive beams, the Facility for Rare isotope Beams (FRIB). FRIB is a next-generation machine that will advance understanding of rare nuclear isotopes and the evolution of the cosmos by providing beams of rare isotopes with neutron and proton numbers far from those of stable nuclei in order to test the limits of nuclear existence.

Research

Low Energy research groups are supported at ANL, BNL, LBNL, LANL, LLNL, PNNL, and ORNL, as well as 46 university grants. The subprogram funds about 170 Ph.D. scientists and nearly 100 graduate students at universities and national laboratories. About two-thirds of the supported scientists conduct nuclear structure and astrophysics research primarily using specialized instrumentation at the ATLAS national user facility as well as smaller accelerator facilities at two university-based Centers of Excellence. The remaining groups conduct research in fundamental symmetries, including experiments at the Fundamental Neutron Physics Beamline (FNPB) at the Spallation Neutron Source, double beta-decay experiments such as the Cryogenic Underground Observatory for Rare Events (CUORE) experiment at Gran Sasso Laboratory in Italy and the Majorana Demonstrator R&D effort at the Sanford Underground Research Facility in Lead, South Dakota, a measurement of the neutrino mass with the Karlsruhe Tritium Neutrino (KATRIN) experiment at the Karlsruhe Institute of Technology in Karlsruhe, Germany, and limited R&D to measure the neutron electric dipole moment.

Operations

ATLAS provides stable and selected radioactive beams and utilizes specialized instrumentation for scientists to conduct research on nuclear structure and nuclear astrophysics. It is the premiere stable beam facility in the world. The Californium Rare Ion Breeder Upgrade (CARIBU) at ATLAS provides targeted unique capabilities to produce radioactive ion beams until FRIB, which will be the most advanced facility for rare ion beams in the world, becomes operational in the next decade. The ATLAS facility nurtures a core competency in accelerator science with superconducting radio frequency cavities for heavy ions that are relevant to the next generation of high-performance proton and heavy-ion linacs. This competency is important to the Office of Science mission and international stable and radioactive ion beam facilities.

Low Energy Nuclear Physics

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Research		
University and laboratory nuclear structure and nuclear astrophysics efforts focus on research at ATLAS, university Centers of Excellence, and support for the development of instrumentation for FRIB. Implementation of scientific instrumentation for neutrino physics and R&D for a next generation double beta decay experiment continue with the start of commissioning of the prototype module for the Majorana Demonstrator. Support is also provided for operations, maintenance, and enhancement of the GRETINA detector; operations of the KATRIN experiment; and operation costs for the CUORE MIE. The neutron program at the FNPB focuses on the fundamental properties of the neutron, and R&D on the feasibility of setting a world leading limit on the electric dipole moment of the neutron (nEDM). University research is increased in FY 2014 to ease the transition to fully funding research awards of $1M or less.	University and laboratory nuclear structure and nuclear astrophysics efforts focus on research at ATLAS, three university Centers of Excellence, and limited support for highest priority development efforts for instrumentation at FRIB. Commissioning of the Majorana Demonstrator continues and data taking is initiated. The international CUORE major item of equipment is completed. Support continues for the GRETINA detector maintenance and operations and KATRIN operations. The neutron program at the FNPB continues R&D on the feasibility of setting a world leading limit on nEDM.	Funding for university research decreases relative to FY 2014. All other research activities are held flat with FY 2014.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Operations		
ATLAS will deliver 3,500 hours (about 22 weeks) of beam time, 83% of optimal operations due to planned downtime for installation of upgrades. A new cryomodule is being installed to provide accelerated stable beams and beams from CARIBU with increased intensity. Accelerator and capital investments continue the energy and efficiency upgrade and the development of an electron beam ion source. Funding continues for the implementation of equipment disposition activities at HRIBF.	ATLAS will provide an estimated 5,900 hours (about 37 weeks) of beam time, 95% of optimal operations. The Electron Beam Ion Source AIP will be commissioned at ATLAS. Funding continues for equipment disposition activities at HRIBF.	A modest increase will maintain critical operations personnel at the ATLAS scientific user facility.

Description

The Nuclear Theory subprogram provides the theoretical support needed to interpret the wide range of data obtained from the experimental nuclear science subprograms and to advance new ideas and hypotheses that identify potential areas for future experimental investigations. Nuclear Theory addresses all three of NP's scientific thrusts. One major theme of theoretical research is the development of an understanding of the mechanisms and effects of quark confinement and deconfinement. A quantitative description of these phenomena through QCD is one of this subprogram's greatest intellectual challenges. New theoretical and computational tools are also being developed to describe nuclear many-body phenomena; these approaches will likely also see important applications in condensed matter physics and in other areas of the physical sciences. Another major research area is nuclear astrophysics, which includes efforts to understand the origins of the elements (e.g., via supernovae) and the consequences that neutrino masses have for nuclear astrophysics.

This subprogram supports the Institute for Nuclear Theory (INT) at the University of Washington. A second round of five-year topical collaborations within the university and national laboratory communities to address high-priority topics in nuclear theory that merit a concentrated theoretical effort will be competed at the end of FY 2015 when the first round of collaborations comes to an end. The Nuclear Theory subprogram also operates the Nuclear Data program through the National Nuclear Data Center (NNDC), which collects, evaluates, and disseminates nuclear physics data for basic nuclear research and for applied nuclear technologies and their development. The extensive nuclear databases maintained and continually updated by the Nuclear Data program are an international resource consisting of carefully organized scientific information gathered from over 100 years of worldwide low-energy nuclear physics experiments.

Much of the research supported by the Nuclear Theory subprogram requires extensive access to leading-edge supercomputers. One area that has a particularly pressing demand for large, dedicated computational resources is LQCD. LQCD calculations are critical for understanding and interpreting many of the experimental results from RHIC, LHC, and CEBAF. A new joint five-year HEP/NP computer hardware project "LQCD-ext II" will be supported starting in FY 2015 to continue providing specialized computing resources for LQCD research, following the previous joint efforts that address the computational requirements of LQCD research. Both HEP and NP require this type of computing capability in order to conduct simulations that address their distinct science programs. The partnering of the two Offices ensures effective coordination to maximize the leverage available for this activity from the infrastructure and intellectual capital of both programs and to prevent duplication of effort on resource-intensive caculations inherently central to quantum chromodyanics and particle physics research.

SciDAC, a collaborative program with ASCR that partners scientists and computer experts in research teams to address major scientific challenges that require supercomputer facilities at the current technological limits, is also supported within this subprogram. The NP SciDAC program operates on a five year cycle, and supports computationally intensive research projects jointly with other SC and DOE offices in areas of mutual interest. SciDAC-3 awards were made in FY 2012 and will continue through FY 2016.

Theory Research

The Nuclear Theory subprogram supports the research programs of approximately 160 university scientists and 120 graduate students at 45 universities, as well as nuclear theory groups at seven national laboratories (ANL, BNL, LANL, LBNL, LLNL, ORNL, and TJNAF). This research has the goals of improving our fundamental understanding of nuclear physics, interpreting the results of experiments carried out under the auspices of the experimental nuclear physics program, and identifying and exploring important new areas of research. It is aligned with the experimental program through the program performance milestones established by the Nuclear Sciences Advisory Committee (NSAC). Three topical collaborations [JET (QCD in the heavy-ion environment); NuN (neutrinos and nucleosynthesis in hot and dense matter); and TORUS (low-energy nuclear reactions for unstable isotopes)] will receive their last year of funding in FY 2014. Based on the success and community support of this program, a new round of 5-year topical collaborations to bring together theorists to address specific high-priority theoretical challenges is planned to be competed late in FY 2015.

Nuclear Data Activities

The Nuclear Data effort involves the work of several national laboratories and universities, and is guided by the DOE-managed National Nuclear Data Center (NNDC) at BNL. The NNDC coordinates the work of the U.S. Nuclear Data Network, a group of DOE-supported individual nuclear data professionals located in universities and national laboratories that perform assessments, validate and estimate uncertainties, and develop modern online dissemination capabilities. The databases developed and maintained by the Nuclear Data program cover over 100 years of nuclear science research with between 1,500 and 6,000 nuclear data retrievals on a daily basis. The NNDC participates in the International Data Committee of the IAEA and is an important national and international resource.

Nuclear Theory

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Theory Research		
Funding supports university and laboratory theoretical efforts for the interpretation of experimental results obtained at NP facilities, including nuclear structure computations with an optimized nuclear force model. Efforts will continue to focus on the research program at the upgraded CEBAF 12 GeV facility, the research program at the future FRIB facility, and topics related to fundamental symmetries. Funding supports ongoing research efforts, the SciDAC-3 grants, and the final year of funding for the topical theory collaborations, as planned. University research is increased in FY 2014 to ease the transition to fully funding research awards of $1M or less.	Funding supports the highest priority theoretical research at universities and national laboratories for the interpretation of experimental results obtained at NP facilities, including multi-dimensional fluctuating fluid-dynamical calculations to describe relativistic nuclear collisions. Efforts focus on nucleon and nuclear structure, spectroscopy, and reactions in preparation for the research program at the upgraded CEBAF 12 GeV facility, the research program at the planned FRIB facility, and on topics related to fundamental symmetries. Funding supports ongoing research efforts, the SciDAC-3 grants, and the LQCD ext-II computing project.	Funding for university research decreases relative to FY 2014. All other research is held flat with FY 2014.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Nuclear Data Activities		
NNDC efforts focus on updating online databases containing experimental and evaluated nuclear structure data, nuclear reaction cross sections, and nuclear science literature and on maintaining computing infrastructure needed to support important efforts across the national Nuclear Data program. Specifically, nuclear structure and decay data will be evaluated and compiled in the Evaluated Nuclear Structure Data File (ENSDF) database, and bibliographic information and nuclear reaction data will be compiled in the Nuclear Science References (NSR) and Cross-Section Information Standard Retrieval System (CSISRS) databases.	Efforts continue to focus on updating online databases containing experimental and evaluated nuclear structure data, nuclear reaction cross sections, and nuclear science literature and on maintaining computing infrastructure needed to support important efforts across the National Nuclear Data program. Specifically, a new XML-based nuclear data structure model will be developed and incorporated into databases.	Funding is provided to retain NNDC staffing in order to support needed program advances.

Nuclear Physics
Isotope Development and Production for Research and Applications

Description

The Isotope Development and Production for Research and Applications subprogram (Isotope Program) supports the production, distribution, and development of production techniques for radioactive and stable isotopes in short supply and critical to the Nation. Isotopes are commodities of strategic importance for the Nation that are essential for energy exploration and innovation, medical applications, national security, and basic research. The goal of the program is to make key isotopes more readily available to meet U.S. needs. To achieve this goal, the program incorporates all capabilities, including facilities and technical staff, required for supply chain management of critically important isotopes. The subprogram also supports R&D efforts associated with developing new and more cost-effective and efficient production and processing techniques, and on the production of isotopes needed for research purposes. The R&D activities also provide collateral benefits for training, contributing to workforce development, and helping to ensure a future U.S.-based expertise in the fields of nuclear chemistry and radiochemistry. These disciplines are foundational not only to radioisotope production but to many other critical aspects of basic and applied nuclear science as well.

The Isotope Program operates a revolving fund to maintain its financial viability by utilizing a combination of appropriations and revenues from the sale of isotopes and services. These resources are used to maintain the staff, facilities, and capabilities at user-ready levels and to support peer-reviewed research and development activities related to the production of isotopes. Isotopes sold to commercial customers are priced to recover the full cost of production, or the market price (whichever is higher). Research isotopes are sold at reduced cost to ensure high priority research requiring them does not become cost prohibitive. Investments in new capabilities are made to meet the growing demands of the Nation and foster future research in applications that will support national security and the health and welfare of the public.

Isotopes are critical national resources used to improve the accuracy and effectiveness of medical diagnoses and therapy, enhance national security, improve the efficiency of industrial processes, and provide precise measurement and investigative tools for materials, biomedical, environmental, archeological, and other research. Some examples are:

- strontium-82 use for cardiac imaging;
- californium-252 for well logging, medicine, homeland defense, and energy security;
- germanium-68 use for calibrating the growing number of positron imaging scanners;
- berkelium-249, californium-251, and curium-244 use as targets for discovery of new superheavy elements;
- selenium-75 use in industrial radiography;
- actinium-225, bismuth-213, lead-212, thorium-227, and radium-223 use in cancer and infectious disease therapy research;
- nickel-63 use in molecular sensing devices and helium-3 (He-3) as in neutron detectors, both for applications in homeland defense;
- strontium-90 and cobalt-60 use for cancer therapy;
- arsenic-73 use as a tracer for environmental research; and
- silicon-32 use in oceanographic studies related to climate modeling.

Stable and radioactive isotopes are vital to the mission of many Federal agencies including the National Institutes of Health (NIH), the National Institute of Standards and Technology, the Environmental Protection Agency, the Department of Agriculture, the Department of Homeland Security (DHS), NNSA, and DOE Office of Science programs. NP continues to work in close collaboration with these organizations to develop strategic plans for isotope production and to establish effective communication to better forecast isotope needs and leverage resources. For example, a five-year production strategy has been generated with the NIH that identifies the isotopes and projected quantities needed by the medical community in the context of the Isotope Program production capabilities. In addition, NP initiated an annual workshop, attended by representatives of all Federal agencies that require stable and radioactive isotopes to support research and applications within their realms of responsibility, to provide a comprehensive assessment of national needs for isotope products and services. Another example is participation in the White House Office of Science and Technology Policy (OSTP) working group on molybdenum-99 (Mo-99). While the Isotope Program is not responsible for the production of Mo-99, it recognizes the importance of this isotope for the Nation as a diagnostic in cardiac imaging and is working closely with NNSA, the lead entity responsible for domestic Mo-99 production, and is offering technical and management support. NP participates in the international High-Level Group on the Security of Supply of Medical Isotopes lead by the Organisation for Economic Co-operation and Development (OECD). NP participates in the Certified Reference Material Working Group which assures material availability for nuclear forensics applications that support national security missions. NP plays a lead role in a federal working group on the He-3 supply issue involving NNSA, DHS, the Department of Defense, NIH, and many other agencies. The objective of the working group is to ensure that the limited supply of He-3 will be distributed to the highest priority applications and basic research. The Isotope Program packages and distributes the isotope. The Isotope program plays a lead role in working with all of the Federal agencies in forecasting demand for the gas and its allocation.

The National Isotope Development Center (NIDC) is a virtual center that interfacing with the user community and manages the coordination of isotope production across the facilities and business operations involved in the production, sale, and distribution of isotopes. The NIDC includes the Isotope Business Office, which is located at ORNL.

Research

Research is supported to develop new or improved production or separation techniques for high priority isotopes in short supply. Examples of isotope research required to meet national needs include positron-emitting radionuclides to support the rapidly growing area of medical imaging using positron emission tomography (PET), isotopes supporting medical research used to diagnose and treat diseases spread through acts of bioterrorism, alpha-emitting radionuclides exhibiting great potential in disease treatment, research isotopes for various biomedical applications, enriched stable isotopes, and alternative isotope supplies for national security applications and advanced power sources. Priorities in research isotope production are informed by guidance from NSAC. One of the high priorities is to conduct R&D aimed at re-establishing a U.S. capability for stable isotope production. Isotope Program research also provides training opportunities for workforce development in the areas of nuclear chemistry and radiochemistry. These disciplines are essential to the long-term health of the fields of radioisotope production and applications.

Operations

The Isotope Program is steward of the Isotope Production Facility (IPF) at Los Alamos National Laboratory (LANL) and the Brookhaven Linac Isotope Producer (BLIP) facility at BNL and provides support for hot cell facilities for processing and handling irradiated materials and purified products at ORNL, BNL, and LANL. Facilities at other sites are used as needed, such as the Idaho National Laboratory reactor for the production of cobalt-60, the Pacific Northwest National Laboratory for processing and packaging strontium-90, the Y-12 National Security Complex for processing and packaging lithium-6 and lithium-7, and the Savannah River Site for the extraction and distribution of helium-3.

Isotope Development and Production for Research and Applications

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Research		
Support maintains research and development competitive awards at universities and national laboratories, and core laboratory research groups at LANL, BNL, and ORNL. Development of production techniques for alpha-emitters is a high priority, as is R&D aimed at re-establishing a domestic capability for research quantities of stable isotopes. Development of a new target design is conducted to re-establish cobalt-57 production for the medical community.	Support maintains research and development competitive awards and laboratory research groups at LANL, BNL, and ORNL. Development of production techniques for alpha-emitters will continue to be a high priority, as will R&D aimed at re-establishing a domestic capability for research quantities of stable isotopes. Development will be completed for a 100 mA ion source and ion optics for production scale electromagnetic stable isotope separation, which is critical for the re-establishment of enriched stable isotope production in the United States.	Research is held flat with FY 2014.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Operations		
Support continues at constant level of effort for infrastructure and maintenance of facilities, core competencies in isotope production and development, and for the NIDC. National laboratory operations are focused on essential activities required to maintain aging facilities in operational condition. Funding is also provided to support university-based operations in support of isotope production. The isotopes produced will represent a balance of commercial isotopes and high priority research isotopes identified by NSAC and the Federal workshop held January 2012. A major milestone in FY 2014 will be completion of radiological facility equipment refurbishment at HFIR to support production of californium-252 to meet production commitments for FY 2015 through FY 2017.	Support will continue for infrastructure and maintenance of facilities, core competencies in isotope production and development, and for the NIDC. National laboratory operations are focused on essential activities required to maintain aging facilities in operational conditions. Funding is provided to support university-based operations in support of isotope production. The isotopes produced will represent a balance of commercial isotopes and high priority research isotopes, with prioritization informed by NSAC and the Federal workshop in September 2013. A major milestone will be the development of a rubidium metal target at the IPF for increased production of strontium-82 for medical heart imaging.	Funding increases to maintain a constant level of effort for the Isotope Production Facility, the Brookhaven Linac Isotope Producer, and processing capabilities at ORNL, BNL, and LANL, and the NIDC.

Nuclear Physics
Construction

Description

Funding in this subprogram provides for design and construction needed to meet overall objectives of the Nuclear Physics program. Currently NP is supporting two projects.

The 12 GeV CEBAF Upgrade at TJNAF, which was identified in the 2007 NSAC Long-Range Plan as the highest priority for the U.S. Nuclear Physics program, will enable scientists to address one of the mysteries of modern physics—the mechanism of quark confinement. A full assessment of the project baseline was conducted in FY 2013 as a result of the FY 2012 appropriation, which provided $50,000,000, $16,000,000 less than the baseline profile, as well as technical challenges. A revised baseline was approved in September 2013.

The Facility for Rare Isotope Beams is funded through a cooperative agreement with Michigan State University and was established as a control point in the FY 2014 appropriation. Prior to that time, funding for the project was provided within the Low Energy subprogram. FRIB will provide intense beams of rare isotopes for world-leading research opportunities in nuclear structure, nuclear astrophysics, and fundamental symmetry studies that will advance knowledge of the origin of the elements and the evolution of the cosmos. It offers a facility for exploring the limits of nuclear existence and identifying new phenomena, with the possibility that a broadly applicable theory of the structure of nuclei will emerge.

Construction

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
06-SC-01, 12 GeV CEBAF Upgrade, TJNAF		
The new cryomodules will be installed in the accelerator tunnel and commissioning activities will be initiated; experimental equipment will also be procured, fabricated, and installed in support of the upgrade effort in Halls B and C and the new Hall D.	Experimental equipment in Halls B, C, and D will continue to be procured, fabricated, installed, and commissioned. Project work associated with civil and accelerator construction will be minimal in FY 2015 with accelerator commissioning scheduled to be complete in FY 2015. CD-4A (Approve Accelerator Project Completion and Start of Operations for the 12 GeV Project) is planned for the first quarter of FY 2015. The project is working towards completion by the end of FY 2017.	The decrease reflects the approved baseline profile for the project.
14-SC-50, Facility for Rare Isotope Beams (FRIB)		
Civil construction and major procurements commenced following enactment of the appropriation. CD-3b (Approve Start of All Construction) is planned for the fourth quarter of FY 2014 and will allow construction of technical components as well as civil construction.	Civil and technical construction, major procurements, and fabrication of components as required under the baselined FRIB scope continue.	Federal funding ramps up for continued FRIB construction according to the Performance Baseline and funding profile established in August 2013.

Nuclear Physics
Performance Measure

In accordance with the GPRA Modernization Act of 2010, the Department sets targets for, and tracks progress toward, achieving performance goals for each program. For more information, refer to the Department's FY 2013 Annual Performance Report. The following table shows the targets for FY 2013 through FY 2015.

	FY 2013	FY 2014	FY 2015
Performance Goal (Measure)	**NP Facility Operations—Average achieved operation time of NP user facilities as a percentage of total scheduled annual operation time.**		
Target	≥ 80%	≥ 80%	≥ 80%
Result	Met	TBD	TBD
Endpoint Target	Many of the research projects that are undertaken at the Office of Science's scientific user facilities take a great deal of time, money, and effort to prepare and regularly have a very short window of opportunity to run. If the facility is not operating as expected the experiment could be ruined or critically setback. In addition, taxpayers have invested millions or even hundreds of millions of dollars in these facilities. The greater the period of reliable operations, the greater the return on the taxpayers' investment.		
Performance Goal (Measure)	**NP Construction/MIE Cost & Schedule—Cost-weighted mean percentage variance from established cost and schedule baselines for major construction, upgrade, or equipment procurement projects.**		
Target	< 10%	< 10%	< 10%
Result	Met	TBD	TBD
Endpoint Target	Adhering to the cost and schedule baselines for a complex, large scale, science project is critical to meeting the scientific requirements for the project and for being good stewards of the taxpayers' investment in the project.		

	FY 2013	FY 2014	FY 2015
Performance Goal (Measure)	**Conduct fundamental research to discover, explore, and understand all forms of nuclear matter.**		
Target	Complete initial measurements with high resolving power tracking array, GRETINA, for sensitive studies of structural evolution and production of superheavy elements.	Perform mass measurements and nuclear reaction studies to infer weak interaction rates in nuclei in order to constrain models of supernovae and stellar evolution.	Measure bulk properties, particle spectra, correlations and fluctuations in gold + gold collisions at Relativistic Heavy Ion Collider (RHIC) to search for evidence of a critical point in the Quantum Chromodynamics (QCD) matter phase diagram.
Result	Met	TBD	TBD
Endpoint Target	Increase the understanding of the existence and properties of nuclear matter under extreme conditions, including that which existed at the beginning of the universe.		

Nuclear Physics Capital Summary ($K)

	Total	Prior Years	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs FY 2014 Enacted
Capital Operating Expenses Summary							
Capital equipment	n/a	n/a	16,603	18,937	18,937	16,428	-2,509
General plant projects (GPP)	n/a	n/a	2,500	2,500	2,500	2,000	-500
Accelerator improvement projects (AIP)	n/a	n/a	4,200	4,370	4,370	4,249	-121
Total, Capital Operating Expenses	**n/a**	**n/a**	**23,303**	**25,807**	**25,807**	**22,677**	**-3,130**

	Total	Prior Years	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs FY 2014 Enacted
Capital Equipment							
Major items of equipment (TEC over $2 million)							
STAR Heavy Flavor Tracker, BNL (TPC $15,480)	15,200	6,800	3,730	0	0	0	0
Other capital equipment projects under $2 million TEC	n/a	n/a	12,873	18,937	18,937	16,428	-2,509
Total, Capital Equipment	**n/a**	**n/a**	**16,603**	**18,937**	**18,937**	**16,428**	**-2,509**

STAR Heavy Flavor Tracker (HFT), BNL: This MIE will fabricate a high-precision tracking and vertexing device based on ultra-thin silicon pixel and pad detectors in the STAR detector. It received CD-2/3 approval in October 2011. The project is scheduled for completion in FY 2015, but is on track to be completed early.

	Total	Prior Years	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs FY 2014 Enacted
General Plant Projects							
General plant projects under $5 million TEC	n/a	n/a	2,500	2,500	2,500	2,000	-500
Accelerator Improvement Projects (AIP)							
RHIC Low Energy Electron Cooling	9,900	0	1,300	2,300	2,300	2,300	0
Other projects under $5 million TEC	n/a	n/a	2,900	2,070	2,070	1,949	-121
Total, Accelerator Improvement Projects	**n/a**	**n/a**	**4,200**	**4,370**	**4,370**	**4,249**	**-121**

Nuclear Physics Construction Projects Summary ($K)

	Total	Prior Years	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs FY 2014 Enacted
06-SC-01, 12 GeV CEBAF Upgrade, TJNAF							
TEC	310,500	220,428	40,572	25,500	25,500	16,500	-9,000
OPC	27,500	10,500	2,500	4,500	4,500	4,500	0
TPC[a]	338,000	230,928	43,072	30,000	30,000	21,000	-9,000
14-SC-50, Facility for Rare Isotope Beams							
DOE TPC	635,500[b]	51,000[c]	22,000[c]	55,000	55,000	90,000	+35,000
Total, Construction (TPC)	**n/a**	**n/a**	**65,072**	**85,000**	**85,000**	**111,000**	**+26,000**

Nuclear Physics Funding Summary ($K)

	FY 2013 Current	FY 2014 Enacted	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Research	162,691	170,369	166,009	-4,360
Scientific User Facilities Operations	249,573	276,811	278,663	+1,852
Other Facility Operations	24,898	24,120	24,566	+446
Projects				
Major Items of Equipment	3,730	0	0	0
Facility for Rare Isotope Beams	22,000	55,000	90,000	+35,000
12 GeV Upgrade TEC	40,572	25,500	16,500	-9,000
Total Projects	66,302	80,500	106,500	+26,000
Other[d]	3,784	17,338	17,835	+497
Total Nuclear Physics	**507,248**	**569,138**	**593,573**	**+24,435**

[a] The TPC reflects the revised baseline that was approved in September 2013.

[b] This is the DOE TPC; MSU's cost share is $94,500,000 bringing the total project cost to $730,000,000. FRIB is funded with operating dollars through a Cooperative Agreement financial assistance award with a work breakdown structure (WBS) that is slightly different from typical federal capital assets. The WBS totals $730,000,000 including MSU's cost share. Because the WBS scope is not pre-assigned to DOE or MSU funds, DOE's baseline of $635,500,000 can not be broken down between TEC and OPC.

[c] The PY and FY 2013 funding was provided within the Low Energy subprogram. The FY 2014 appropriation established FRIB as a control point.

[d] Includes SBIR/STTR funding in FY 2014–FY 2015.

Scientific User Facility Operations ($K)

	FY 2013 Current	FY 2014 Enacted	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
CEBAF (TJNAF)[a]	**$89,907**	**$106,237**	**$107,025**	**+$788**
Achieved operating hours	0	N/A	N/A	
Planned operating hours	0	0	0	0
Optimal hours	0	0	0	0
Percent of optimal hours	N/A	N/A	N/A	
Unscheduled downtime	N/A	N/A	N/A	
Number of users	1,260	1,245	1,235	-10
RHIC (BNL)	**$165,831**	**$172,079**	**$172,079**	**0**
Achieved operating hours	2,238	N/A	N/A	
Planned operating hours	2,100	2,770	2,770	0
Optimal hours	4,100	4,100	4,100	0
Percent of optimal hours	54.6%	67.6%	67.6%	
Unscheduled downtime	17.2%	N/A	N/A	
Number of users	1,200	1,200	1,200	0
ATLAS (ANL)[b]	**$21,098**	**$21,887**	**$22,182**	**+$295**
Achieved operating hours	4,104	N/A	N/A	
Planned operating hours	3,500	3,500	5,900	+2,400
Optimal hours	4,200	4,200	6,200	+2,000
Percent of optimal hours	97.7%	83.3%	95.2%	
Unscheduled downtime	10.6%	N/A	N/A	
Number of users	400	400	400	0

[a] During FY 2013 through FY 2015, there will be no research hours to which the CEBAF facility will be held accountable while the 12 GeV upgrade is commissioned and reliability is expected to be low. In FY 2014, 14 weeks of beam development and tuning are supported as the facility comes back on from a prolonged shutdown. In FY 2015, approximately 16 weeks of machine development are supported. The user community is expected to remain active during the shutdown with instrumentation and equipment implementation for the upgraded facility so they continue to be shown in these years.

[b] The optimal hours at ATLAS in FY 2013–2015 vary due to downtime for installation of upgrades.

	FY 2013 Current	FY 2014 Enacted	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Total Scientific User Facility Operations	**$276,836**	**$300,203**	**$301,286**	**+$1,083**
Achieved operating hours	6,342	N/A	N/A	
Planned operating hours	5,600	6,270	8,670	+2,400
Optimal hours	8,300	8,300	10,300	+2,000
Percent of optimal hours (funding weighted)	59.5%	69.3%	70.7%	
Unscheduled downtime	27.8%	N/A	N/A	
Number of users	2,860	2,845	2,835	-10

Scientific Employment[a]

	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	FY 2015 vs. FY 2014
Number of permanent Ph.D.'s (FTEs)	735	715	700	-15
Number of postdoctoral associates (FTEs)	320	300	285	-15
Number of graduate students (FTEs)	525	480	440	-40
Number of Ph.D.'s awarded	85	85	85	0

[a] This table does not include approximately 1,000 engineering, technical, and administrative FTEs that are supported by the NP program.

14-SC-50, Facility for Rare Isotope Beams (FRIB) at Michigan State University (MSU)
East Lansing, MI
Project is for a Cooperative Agreement

1. Significant Changes

This is a new project data sheet (PDS) resulting from the FY 2014 appropriation, which established a control point for the Facility for Rare Isotope Beams (FRIB). However, this PDS does not represent a new start for FRIB. Funds were appropriated for this project in FY 2009 through FY2013 within the Nuclear Physics Low Energy subprogram.

The most recent approved Critical Decision (CD) for the Facility for Rare Isotope Beams (FRIB) project is CD-2/3A (Approve Performance Baseline/Approve Start of Civil Construction) which was approved on August 1, 2013, with a DOE Total Project Cost (TPC) of $635,500,000 and CD-4 by 3Q FY 2022. In addition, Michigan State University (MSU) is providing a cost share of $94,500,000, bringing the total project cost to $730,000,000. FRIB is funded through a cooperative agreement financial assistance award with MSU per 10 CFR 600, and the project is required by this agreement to follow the principles of the DOE Order 413.3B. Funding tables contained in sections 3, 5, and 6 of this PDS differ slightly in how the baseline is presented from a traditional PDS for a federal capital asset construction project.

Following enactment of the FY 2014 appropriation, the Acquisition Executive authorized the start of civil construction. There are no changes in the scope, cost, and schedule since the establishment of this project's baseline on August 1, 2013.

A Federal Project Director has been assigned to this project.

2. Critical Decision (CD) and D&D Schedule

(fiscal quarter or date)

	CD-0	CD-1	Design Complete	CD-2/3A	CD-3B	CD-4	D&D
FY 2011	2/9/2004	4Q FY 2010	TBD	TBD	TBD	FY 2017–2019	N/A
FY 2012	2/9/2004	9/1/2010	TBD	4Q FY 2012	TBD	FY 2018–2020	N/A
FY 2013	2/9/2004	9/1/2010	TBD	TBD	TBD	TBD	N/A
FY 2014	2/9/2004	9/1/2010	TBD	3Q FY 2013	TBD	TBD	N/A
FY 2015	2/9/2004	9/1/2010	4Q FY 2014[a]	8/1/2013	4Q FY 2014	3Q FY 2022	N/A[b]

CD-0 – Approve Mission Need
CD-1 – Approve Alternative Selection and Cost Range
CD-2 – Approve Performance Baseline
CD-3A – Approve Start of Civil Construction
CD-3B – Approve Start of Technical Construction
CD-4 – Approve Start of Operations or Project Closeout
D&D Start – Start of Demolition & Decontamination (D&D) work
D&D Complete –Completion of D&D work

[a] This date represents when the design will be substantially complete to allow the start of technical construction (CD-3B). A limited amount of design effort will continue through 4Q FY 2017.
[b] MSU is responsible for the D&D of the facility.

3. Baseline and Validation Status[a]

(dollars in thousands)

	Design/ Construction	R&D/Conceptual Design/NEPA	Pre-Operations	Total TPC	Less MSU Cost Share	DOE TPC
FY 2015	655,700	24,600	49,700	730,000	-94,500	635,500

4. Project Description, Scope, and Justification

Mission Need

FRIB will provide intense beams of rare isotopes for a wide variety of studies in nuclear structure, nuclear astrophysics, and other topics in nuclear physics. This facility will impact the study of the origin of the elements and the evolution of the cosmos, and offers an opportunity for exploring the limits of nuclear existence and identifying new phenomena, with the possibility that a more broadly applicable theory of nuclei will emerge. The facility will offer new glimpses into the origin of the elements, leading to a better understanding of key issues by creating exotic nuclei that, until now, have existed only in nature's most spectacular explosion, the supernova.

Scope and Justification for 14-SC-50, Facility for Rare Isotope Beams (FRIB)

The science which underlies the FRIB mission is a core competency of nuclear physics: understanding how protons and neutrons combine to form various nuclear species; understanding how long chains of different nuclear species survive; and understanding how one nuclear species decays into another and what is emitted when that happens. Forefront knowledge and capability in this competency is essential, both for U.S. leadership in this scientific discipline and to provide the knowledge and workforce needed for numerous activities and applications relevant to national security and economic competitiveness.

FRIB is optimized to produce large quantities of a wide variety of rare isotopes by breaking stable nuclei into rare isotopes. High intensity primary beams of stable isotopes are produced in Electron Cyclotron Resonator (ECR) ion sources and accelerated up to a minimum energy of 200 MeV per nucleon by a superconducting linear accelerator capable of delivering 400 kW of beam power at full energy. Secondary beams of rare isotopes are produced "in-flight" and separated from unwanted fragments by magnetic analysis. These rare isotope beams are delivered to experimental areas or stopped in a suite of ion-stopping stations where they can be extracted and used for experiments at low energy, or reaccelerated for astrophysical experiments or for nuclear structure experiments. The project includes the necessary infrastructure and support facilities for operations and the 1,000-person user community.

CD-4 Key Performance Parameters

System	Parameter	Performance Criteria
Accelerator System	Accelerate heavy-ion beam	Measure FRIB driver linac Argon-36 beam with energy larger than 200 MeV per nucleon and a beam current larger than 20 pico nano amps (pnA).

[a] Because this project is funded with operating dollars through a financial assistance award, its baseline is categorized through a work breakdown structure (WBS), which is slightly different from typical federal capital assets. Note that the project's WBS totals $730,000,000 including MSU's cost share. The WBS scope is not pre-assigned to DOE or MSU funds.

System	Parameter	Performance Criteria
Experimental Systems	Produce a fast rare isotope beam of Selenium-84	Detect and identify Selenium-84 isotopes in FRIB fragment separator focal plane
	Stop a fast rare isotope beam in gas and reaccelerate a rare isotope beam	Measure reaccelerated rare isotope beam energy larger than 3 MeV per nucleon
Conventional Facilities	Linac tunnel	Beneficial occupancy of subterranean tunnel structure of approximately 500 feet path length (minimum) to house FRIB driver linear accelerator
	Cryogenic helium liquefier plant—building and equipment	Beneficial occupancy of the cryogenic helium liquefier plant building and installation of the helium liquefier plant complete
	Target area	Beneficial occupancy of target area and one beam line installed and ready for commissioning

As contractually required under the financial assistance award agreement, FRIB is being conducted in accordance with the project management principles in DOE O 413.3B, Program and Project Management for the Acquisition of Capital Assets, and all appropriate project management requirements have been met.

5. Financial Schedule[a]

(dollars in thousands)

	Appropriations	Obligations	Costs
DOE Total Project Cost (TPC)			
FY 2009	7,000	7,000	1,874
FY 2010	12,000	12,000	13,838
FY 2011	10,000	10,000	13,288
FY 2012	22,000	22,000	19,506
FY 2013	22,000	22,000	22,260
FY 2014[b]	55,000	55,000	57,234
FY 2015	90,000	90,000	90,000
FY 2016	100,000	100,000	100,000
FY 2017	100,000	100,000	100,000
FY 2018	97,200	97,200	97,200
FY 2019	75,000	75,000	75,000
FY 2020	40,000	40,000	40,000
FY 2021	5,300	5,300	5,300
Total, DOE TPC	635,500	635,500	635,500

[a] The funding profile represents DOE's portion of the baselined TPC to be provided through federal appropriations.
[b] This is the first project data sheet submitted for FRIB. It was established as a control point in the FY 2014 appropriation. Funding for the project in FY 2013 and prior years was provided within the Low Energy subprogram.

6. Details of Project Cost Estimate[a]

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Design & Construction			
Management and Support	35,200	N/A	35,200
Conventional Facilities	165,300	N/A	165,300
Accelerator Systems	241,400	N/A	241,400
Experimental Systems	55,000	N/A	55,000
Contingency (DOE Held)	158,650	N/A	158,650
Total, Design & Construction	655,700	N/A	655,700
Contingency, Design & Construction (DOE Held)	158,650	N/A	158,650
Other Costs			
Conceptual Design/Tech R&D/NEPA	24,600	N/A	24,600
Pre-ops/Commissioning/Spares	35,500	N/A	35,500
Contingency (DOE Held)	14,150	N/A	14,150
Total, Other Costs	64,100	N/A	64,100
Contingency, Other Costs (DOE Held)	14,150	N/A	14,150
Total, TPC	730,000	N/A	730,000
Less MSU Cost Share	-94,500	N/A	-94,500
Total, DOE TPC	635,500	N/A	635,500
Total, Contingency (DOE Held)	172,800	N/A	172,800

[a] This section shows a breakdown of the total project cost of $730,000,000, which includes MSU’s cost share. The scope of work is not pre-assigned to DOE or MSU funds.

7. Schedule of Appropriation Requests[a]

(dollars in thousands)

Request Year		Prior Years	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	Outyears	Total
FY 2011	TPC	29,000	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
FY 2012	TPC	59,000	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
FY 2013	TPC	51,000	22,000	TBD	TBD	TBD	TBD	TBD	TBD	TBD
FY 2014	TPC	51,000	22,000	55,000	TBD	TBD	TBD	TBD	TBD	TBD
FY 2015 PB[b]	TPC	51,000	22,000	55,000	90,000	100,000	100,000	97,200	120,300	635,500

8. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy	2Q FY2022
Expected Useful Life	20 Years
Expected Future Start of D&D of this capital asset	NA[c]

(Related Funding requirements)

(dollars in thousands)

	Annual Costs		Life Cycle Costs	
	Current Total Estimate	Previous Total Estimate	Current Total Estimate	Previous Total Estimate
Operations[d]	90,000	N/A	1,800,000[e]	N/A

9. Required D&D Information

The FRIB project is being constructed at MSU under a cooperative agreement financial assistance award. The one-for-one requirement is not applicable, since this is not a federal capital acquisition. MSU is responsible for the D&D of the facility.

10. Acquisition Approach

FRIB project activities, such as the construction of conventional facilities, will be accomplished following all procurement requirements, which include using fixed-priced competitive contracts with selection based on best value. MSU has contracted for the services of an architect-engineer firm for the design of the conventional facilities. The Driver Linac and Experimental System components will be self-performed by the MSU design staff with assistance from outside vendors and from DOE national laboratories that possess specific areas of unique expertise unavailable from commercial sources.

[a] The funding profile represents DOE's portion of the baselined TPC to be provided through federal appropriations.
[b] The Performance Baseline was approved August 1, 2013. This is the first project data sheet submitted for FRIB. It was established as a control point in the FY 2014 appropriation. Funding for the project prior to that time was provided within the Low Energy subprogram.
[c] Per the financial assistance award agreement, MSU is responsible for D&D.
[d] Utilities, maintenance, and repair costs are included within the Operations amounts.
[e] The total operations and maintenance (O&M) is estimated at an average annual cost of approximately $90,000,000 (including escalation) over 20 years.

Integration of the conventional facilities with the Driver Linac and Experimental Systems will be accomplished by the MSU FRIB Project Team.

06-SC-01, 12 GeV CEBAF Upgrade, Thomas Jefferson National Accelerator Facility
Newport News, Virginia
Project is for Design and Construction

1. Summary and Significant Changes

The most recent DOE O 413.3B approved Critical Decision (CD) is CD-3, Approve Start of Construction, which was signed on September 15, 2008, with a Total Project Cost (TPC) of $310,000,000 and a planned CD-4, Approve Project Completion, in the third quarter of FY 2015. A baseline change was required as a result of the FY 2012 appropriation which provided $16,000,000 less than the baseline profile. Because of this directed change and technical and performance challenges associated with the procurement of seven superconducting magnets, the project underwent several reviews during FY 2013 to rebaseline the project's cost and schedule. A baseline change was approved on September 4, 2013, and is reflected in this project datasheet. It increases the TPC by $28,000,000 to a total of $338,000,000, and extends the project CD-4B completion date by 27 months to September 2017. There are no changes to the original performance deliverables established at CD-2. Risks continue to be closely monitored, and include challenges with the procurement and installation of components, schedule, and impacts of funding uncertainty. For each moderate and high risk, a mitigation plan is developed in order to optimize successful project completion

The Federal Project Director (FPD) continues to be mentored as he works from his current Level 2 certification toward certification Level 3, anticipated by the Summer of 2014,.

This project data sheet (PDS) does not include a new start for the budget year; it is an update of the FY 2014 PDS.

2. Critical Decision (CD) and D&D Schedule

(fiscal quarter or date)

	CD-0	CD-1	Design Complete	CD-2	CD-3	CD-4A	CD-4B	D&D
FY 2007	3/31/2004	1Q FY 2007	4Q FY 2009	4Q FY 2007	4Q FY 2008	N/A	1Q FY 2014	N/A
FY 2008	3/31/2004	2/14/2006[a]	4Q FY 2009	4Q FY 2007	4Q FY 2008	N/A	1Q FY 2015	N/A
FY 2009	3/31/2004	2/14/2006	4Q FY 2009	11/9/2007	4Q FY 2008	N/A	3Q FY 2015	N/A
FY 2010	3/31/2004	2/14/2006	4Q FY 2009	11/9/2007	9/15/2008	1Q FY 2015	3Q FY 2015	N/A
FY 2011	3/31/2004	2/14/2006	1Q FY 2010	11/9/2007	9/15/2008	1Q FY 2015	3Q FY 2015	N/A
FY 2012	3/31/2004	2/14/2006	12/31/2009	11/9/2007	9/15/2008	1Q FY 2015	3Q FY 2015	N/A
FY 2013	3/31/2004	2/14/2006	12/31/2009	11/9/2007	9/15/2008	1Q FY 2015	3Q FY 2015	N/A
FY 2014[b]	3/31/2004	2/14/2006	12/31/2009	11/9/2007	9/15/2008	1Q FY 2015	3Q FY 2015	N/A
FY 2015	3/31/2004	2/14/2006	12/31/2009	11/9/2007	9/15/2008	1Q FY 2015	4Q FY 2017	N/A

CD-0 – Approve Mission Need
CD-1 – Approve Alternative Selection and Cost Range
CD-2 – Approve Performance Baseline

[a] CD-1 was approved on 2/14/2006. Engineering and design activities started in 4Q FY 2006 after Congress approved the Department of Energy's request to reprogram $500,000 within the FY 2006 funding for Nuclear Physics, per direction contained in H.Rpt 109–275.
[b] The CD-4B date did not reflect the impact resulting from the reduced FY 2012 funding, which has since been assessed in a rebaseline in FY 2013 and is reflected in the FY 2015 data in this table.

CD-3 – Approve Start of Construction
CD-4 – Approve Start of Operations or Project Closeout
D&D– Demolition & Decontamination (D&D) work

3. Baseline and Validation Status

(dollars in thousands)

	TEC, Design	TEC, Construction	TEC, Total	OPC Except D&D	OPC, D&D	OPC, Total	TPC
FY 2007	21,000	TBD	TBD	11,000	TBD	TBD	TBD
FY 2008	21,000	TBD	TBD	10,500	TBD	TBD	TBD
FY 2009	21,000	266,500	287,500	22,500	N/A	22,500	310,000
FY 2010	21,000	266,500	287,500	22,500	N/A	22,500	310,000
FY 2011	21,000	266,500	287,500	22,500	N/A	22,500	310,000
FY 2012	21,000	266,500	287,500	22,500	N/A	22,500	310,000
FY 2013	21,000	266,500	287,500	22,500	N/A	22,500	310,000
FY 2014	21,000	266,500	287,500	22,500	N/A	22,500	310,000
FY 2015[a]	21,000	289,500	310,500	27,500	N/A	27,500	338,000

4. Project Description, Scope, and Justification

Mission Need

The Continuous Electron Beam Accelerator Facility (CEBAF) at the Thomas Jefferson National Accelerator Facility is the world-leading facility for the experimental study of the structure of matter governed by the "strong force." An energy upgrade of CEBAF was identified by the nuclear science community as a compelling scientific opportunity. In particular, the Nuclear Science Advisory Committee (NSAC) stated in the 1996 Long Range Plan that "…the community looks forward to future increases in CEBAF's energy, and to the scientific opportunities that would bring." In the 2007 Long Range Plan, NSAC concluded that completion of the 12 GeV CEBAF Upgrade project was the highest priority for the Nation's nuclear science program.

Scope and Justification for 06-SC-01, 12 GeV CEBAF Upgrade

The 12 GeV CEBAF Upgrade directly supports the Nuclear Physics mission and addresses the objective to measure properties of the proton, neutron, and simple nuclei for comparison with theoretical calculations to provide an improved quantitative understanding of their quark substructure.

The scope of the project includes upgrading the electron energy capability of the main accelerator from 6 GeV to 12 GeV, building a new experimental hall (Hall D) and associated beam-line, and enhancing the capabilities of the existing experimental halls to support the most compelling nuclear physics research.

[a] The amounts reflect the revised baseline approved in September 2013. A Work-for-Others agreement was approved by DOE that provides $9,000,000 appropriated by the Commonwealth of Virginia to leverage the federal investment for an upgrade of the Jefferson Lab's research facilities. This funding is outside the DOE baseline cost and schedule.

CD-4A Key Performance Parameters

Subsystem	Technical Definition of Completion
Accelerator	12 GeV capable 5.5 pass machine installed
	11 GeV capable beam line to existing Halls A, B, and C installed
	12 GeV capable beam line to new Hall D tagger area installed
	Accelerator commissioned by transporting a ≥ 2 nA electron beam at 2.2 GeV (1pass)
Conventional Facilities	New Experimental Hall D and the Counting House: ≥ 10,500 square feet.

CD-4B Key Performance Parameters

Subsystem	Technical Definition of Completion
Hall B	Detector operational: events recorded with a ≥ 2 nA electron beam at > 6 GeV beam energy (3 pass)
Hall C	Detector operational: events recorded with a ≥ 2 nA electron beam at > 6 GeV beam energy (3 pass)
Hall D	Detector operational: events recorded with a ≥ 2 nA electron beam at > 10 GeV beam energy (5.5 pass)

Key Performance Parameters to achieve CD-4 are phased between the accelerator and conventional facilities (CD-4A) and the experimental equipment in Halls B, C, and D (CD-4B). The deliverables defining completion are identified in the Project Execution Plan and have not changed since CD-2. Mitigation plans exist for identified risks to help ensure successful project completion after approval of a baseline change proposal due to the directed change and technical challenges.

The project is being conducted in accordance with the project management requirements in DOE O 413.3B, *Program and Project Management for the Acquisition of Capital Assets*, and all appropriate project management requirements have been met.

5. Financial Schedule

(dollars in thousands)

	Appropriations	Obligations	Recovery Act Costs	Costs
Total Estimated Cost (TEC)				
Design				
FY 2006	500	500	0	88
FY 2007	7,000	7,000	0	6,162
FY 2008	13,377[a]	13,377	0	9,108
FY 2009	123[a]	123	0	5,370
FY 2010	0	0	0	265
FY 2011	0	0	0	7
Total, Design	21,000	21,000	0	21,000

[a] The baseline FY 2008 PED funding was reduced by $123,000 as a result of a FY 2008 rescission. This reduction was restored in FY 2009 to maintain the TEC and project scope.

(dollars in thousands)

	Appropriations	Obligations	Recovery Act Costs	Costs
Construction				
FY 2009	28,500	28,500	0	5,249
FY 2009 Recovery Act	65,000	65,000	2,738	0
FY 2010	20,000	20,000	29,621	18,642
FY 2011[a]	35,928	35,928	25,890	40,801
FY 2012	50,000	50,000	5,203	45,537
FY 2013	40,572	40,572	1,545	51,211
FY 2014	25,500	25,500	3	27,060
FY 2015	16,500	16,500	0	21,500
FY 2016	7,500	7,500	0	12,500
FY 2017	0	0	0	2,000
Total, Construction	289,500	289,500	65,000	224,500
TEC				
FY 2006	500	500	0	88
FY 2007	7,000	7,000	0	6,162
FY 2008	13,377	13,377	0	9,108
FY 2009	28,623	28,623	0	10,619
FY 2009 Recovery Act	65,000	65,000	2,738	0
FY 2010	20,000	20,000	29,621	18,907
FY 2011	35,928	35,928	25,890	40,808
FY 2012	50,000	50,000	5,203	45,537
FY 2013	40,572	40,572	1,545	51,211
FY 2014	25,500	25,500	3	27,060
FY 2015	16,500	16,500	0	21,500
FY 2016	7,500	7,500	0	12,500
FY 2017	0	0	0	2,000
Total, TEC	310,500	310,500	65,000	245,500

[a] The baseline FY 2011 funding was reduced by $72,000 as a result of a FY 2011 rescission.

	(dollars in thousands)			
	Appropriations	Obligations	Recovery Act Costs	Costs
Other Project Cost (OPC)				
OPC except D&D				
FY 2004	700	700	0	77
FY 2005	2,300	2,300	0	2,142
FY 2006	4,000	4,000	0	3,508
FY 2007	2,500	2,500	0	2,751
FY 2008	1,000	1,000	0	1,802
FY 2009	0	0	0	155
FY 2010	0	0	0	62
FY 2013	2,500	2,500	0	2,178
FY 2014	4,500	4,500	0	4,425
FY 2015	4,500	4,500	0	4,500
FY 2016	4,500	4,500	0	4,500
FY 2017	1,000	1,000	0	1,400
Total, OPC	27,500	27,500	0	27,500
Total Project Cost				
FY 2004	700	700	0	77
FY 2005	2,300	2,300	0	2,142
FY 2006	4,500	4,500	0	3,596
FY 2007	9,500	9,500	0	8,913
FY 2008	14,377	14,377	0	10,910
FY 2009	28,623	28,623	0	10,774
FY 2009 Recovery Act	65,000	65,000	2,738	0
FY 2010	20,000	20,000	29,621	18,969
FY 2011	35,928	35,928	25,890	40,808
FY 2012	50,000	50,000	5,203	45,537
FY 2013	43,072	43,072	1,545	53,389
FY 2014	30,000	30,000	3	31,485
FY 2015	21,000	21,000	0	26,000
FY 2016	12,000	12,000	0	17,000
FY 2017	1,000	1,000	0	3,400
Total, TPC[a]	338,000	338,000	65,000	273,000

[a] The TPC reflects the revised baseline approved in September 2013.

6. Details of Project Cost Estimate

	(dollars in thousands)		
	Current Total Estimate	Previous Total Estimate	Original Validated Estimate
Total Estimated Cost (TEC)			
Design			
Design	21,000	21,000	19,200
Contingency	0	0	1,800
Total, Design	21,000	21,000	21,000
Construction Phase			
Construction	30,347	30,306	27,450
Accelerator/Experimental Equipment/Management	243,937	225,059	174,150
Contingency	15,216	11,135	64,900
Total, Construction	289,500	266,500	266,500
Total, TEC	310,500	287,500	287,500
Contingency, TEC	15,216	11,135	66,700
Other Project Cost (OPC)			
OPC except D&D			
Conceptual Design	3,445	3,445	3,500
R&D	7,052	7,052	6,400
Start-up	12,618	11,836	7,450
Contingency	4,385	167	5,150
Total, OPC	27,500	22,500	22,500
Contingency, OPC	4,385	167	5,150
Total, TPC	338,000[a]	310,000	310,000
Total, Contingency	19,601	11,302	71,850

[a] The TPC reflects the revised baseline approved in September 2013.

7. Schedule of Appropriation Requests

(dollars in thousands)

Request Year		Prior Years	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	Total
FY 2007 (Design only)	TEC	21,000	0	0	0	0	0	0	0	0	21,000
	OPC	11,000	0	0	0	0	0	0	0	0	11,000
	TPC	32,000	0	0	0	0	0	0	0	0	32,000
FY 2008 (Design only)	TEC	21,000	0	0	0	0	0	0	0	0	21,000
	OPC	10,500	0	0	0	0	0	0	0	0	10,500
	TPC	31,500	0	0	0	0	0	0	0	0	31,500
FY 2009[a] PB	TEC	49,500	59,000	62,000	66,000	40,500	10,500	0	0	0	287,500
	OPC	10,500	0	0	0	2,500	7,500	2,000	0	0	22,500
	TPC	60,000	59,000	62,000	66,000	43,000	18,000	2,000	0	0	310,000
FY 2010[b]	TEC	114,500	22,000	34,000	66,000	40,500	10,500	0	0	0	287,500
	OPC	10,500	0	0	0	2,500	7,500	2,000	0	0	22,500
	TPC	125,000	22,000	34,000	66,000	43,000	18,000	2,000	0	0	310,000
FY 2011	TEC	114,500	20,000	36,000	66,000	40,500	10,500	0	0	0	287,500
	OPC	10,500	0	0	0	2,500	7,500	2,000	0	0	22,500
	TPC	125,000	20,000	36,000	66,000	43,000	18,000	2,000	0	0	310,000
FY 2012	TEC	114,500	20,000	36,000	66,000	40,500	10,500	0	0	0	287,500
	OPC	10,500	0	0	0	2,500	7,500	2,000	0	0	22,500
	TPC	125,000	20,000	36,000	66,000	43,000	18,000	2,000	0	0	310,000
FY 2013	TEC	114,500	20,000	35,928[c]	50,000	40,572	26,500	0	0	0	287,500
	OPC	10,500	0	0	0	2,500	7,500	2,000	0	0	22,500
	TPC	125,000	20,000	35,928	50,000	43,072	34,000	2,000	0	0	310,000

[a] The FY 2009 Congressional Budget was the first project data sheet to reflect the CD-2 Performance Baseline which was approved in November 2007.

[b] The project received $65,000,000 from the American Recovery and Reinvestment Act of 2009 which advanced a portion of the baselined FY 2010 and FY 2011 planned funding. The FY 2010 and FY 2011 amounts reflect a total of $65,000,000 in reductions to the originally planned baselined funding profile to account for the advanced Recovery Act funding.

[c] The baseline FY 2011 funding was reduced by $72,000 as a result of the FY 2011 rescission.

(dollars in thousands)

Request Year		Prior Years	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	Total
FY 2014	TEC	114,500	20,000	35,928	50,000	50,306	25,500	1,000	0	0	287,500
	OPC	10,500	0	0	0	—	4,500	5,000	0	0	22,500
	TPC[a]	125,000	20,000	35,928	50,000	50,306[b]	30,000	6,000	0	0	310,000
FY 2015	TEC	114,500	20,000	35,928	50,000	40,572	25,500	16,500	7,500	0	310,500
	OPC	10,500	0	0	0	2,500	4,500	4,500	4,500	1,000	27,500
	TPC[c]	125,000	20,000	35,928	50,000	43,072	30,000	21,000	12,000	1,000	338,000

8. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy (fiscal quarter or date)	4Q FY 2017
Expected Useful Life (number of years)	15
Expected Future start of D&D for new construction (fiscal quarter)	N/A

(Related Funding Requirements)

(dollars in thousands)

	Annual Costs		Life cycle costs	
	Current Total Estimate	Previous Total Estimate	Current Total Estimate	Previous Total Estimate
Operations	150,000	150,000	2,250,000[d]	2,250,000
Maintenance	Included above	Included above	Included above	Included above
Total, Operations & Maintenance	150,000	150,000	2,250,000	2,250,000

[a] The TPC did not reflect the estimated impact resulting from the reduced FY 2012 funding, which has since been assessed and a rebaseline was approved in September 2013.

[b] The FY 2013 amount shown reflected the P.L. 112-175 continuing resolution level annualized to a full year. The TEC, TPC, and outyear appropriation assumptions had not been adjusted to reflect the final FY 2013 funding level; the FY 2013 Request level of $40,572,000 for TEC, $2,500,000 for OPC, and $43,072,000 for TPC was assumed.

[c] The TPC reflects the revised baseline approved in September 2013.

[d] The total operations and maintenance (O&M) is estimated at an average annual cost of approximately $150,000,000 (including escalation) over 15 years. Almost 90% of the O&M cost would still have been required had the existing accelerator not been upgraded and instead continued operations at 6 GeV.

9. Required D&D Information

	Square Feet
Area of new construction	31,500
Area of existing facility(ies) being replaced and D&D'd by this project	0
Area of other D&D outside the project	0
Area of additional D&D space to meet the "one-for-one" requirement taken from the banked area.	31,500

The "one-for-one" requirement is met by offsetting 31,500 square feet of the 80,000 square feet of banked space that was granted to Jefferson Laboratory in a Secretarial waiver.

10. Acquisition Approach

The Acquisition Strategy was approved February 14, 2006 with CD-1 approval. All acquisitions are managed by Jefferson Science Associates with appropriate Department of Energy oversight. Cost, schedule, and technical performance are monitored using an earned-value process that is described in the Jefferson Lab Project Control System Manual and consistent with DOE O 413.3B, Program and Project Management for the Acquisition of Capital Assets. The procurement practice uses firm fixed-price purchase orders and subcontracts for supplies, equipment, and services and makes awards through competitive solicitations. Project and design management, inspection, coordination, tie-ins, testing and checkout witnessing, and acceptance are performed by Jefferson Laboratory and Architectural-Engineering subcontractors as appropriate.

Workforce Development for Teachers and Scientists

Overview

The Workforce Development for Teachers and Scientists (WDTS) program mission is to help ensure that DOE has a sustained pipeline of science, technology, engineering, and mathematics (STEM) workers. This is accomplished through support of undergraduate internships, graduate thesis research, and visiting faculty programs at the DOE laboratories; the Albert Einstein Distinguished Educator Fellowship for K–12 STEM teachers, administered by WDTS for DOE and for a number of other federal agencies; and annual, nationwide, middle- and high-school science competitions culminating in the National Science Bowl® in Washington D.C. These investments help develop the next generation of scientists and engineers to support the DOE mission, administer programs, and conduct research.

WDTS activities rely significantly on DOE's 17 laboratories, which employ more than 30,000 workers with STEM backgrounds. The DOE laboratory system provides access to leading scientists; world-class scientific user facilities and instrumentation; and large-scale, multidisciplinary research programs unavailable in universities or industry. WDTS leverages these assets to develop and train post-secondary students and educators in support of the DOE mission.

Highlights of the FY 2015 Budget Request

Programs conducted at the DOE Laboratories increase in order to support additional highly qualified applicants to conduct research in mission-critical areas at the DOE laboratories. The pool of highly qualified applicants is growing, as are placement opportunities at DOE host laboratories. The FY 2015 Request supports growth while maintaining programmatic standards of quality and impact for these experience-based STEM learning opportunities.

Description

<u>Activities at the DOE Laboratories</u>

Activities include the Science Undergraduate Laboratory Internships, Community College Internships, Graduate Student Research Program, and Visiting Faculty Program. These activities provide opportunities for participants to engage in research requiring specialized instrumentation; large-scale, multidisciplinary efforts; and/or scientific user facilities. WDTS activities are aligned with the strategic objectives of the National Science and Technology Council Committee on STEM Education (CoSTEM) Federal STEM Education 5-Year Strategic Plan[a].

The **Science Undergraduate Laboratory Internships (SULI)** program goal is to encourage undergraduate students to enter STEM careers especially relevant to the DOE mission by providing research experiences at DOE national laboratories under the direction of scientific and technical laboratory staff who serve as research advisors and mentors. With its long history, the SULI program places undergraduate students in paid internships in science and engineering research activities at DOE laboratories, working with laboratory staff scientists and engineers on projects related to ongoing research programs. Appointments are for 10 weeks during the summer term and 16 weeks during the fall and spring terms.

The **Community College Internships (CCI)** program goal is to encourage community college students to pursue technical careers relevant to the DOE mission by providing technical training experiences at DOE laboratories under the direction of laboratory staff who serve as advisors and mentors. The CCI program places students in paid internships in technologies supporting laboratory work under the supervision of a laboratory technician or researcher. Appointments are for 10 weeks during the summer term and 16 weeks during the planned fall and spring terms.

The **Office of Science Graduate Student Research (SCGSR)** program goal is to enhance graduate student preparedness for STEM careers critically important to the Office of Science mission by providing graduate thesis research opportunities at DOE laboratories. The program provides research awards for graduate students to pursue part of their graduate thesis

[a] http://www.whitehouse.gov/sites/default/files/microsites/ostp/stem_stratplan_2013.pdf

research at a DOE laboratory in areas that address scientific challenges central to the Office of Science mission. Graduate students pursuing Ph.D. degrees in physics, chemistry, materials sciences, non-medical biology, mathematics, computer or computational sciences, or specific areas of environmental sciences aligned with the Office of Science mission are eligible for research awards to conduct part of their graduate thesis research at a DOE laboratory in collaboration with a DOE laboratory scientist. Research award terms range from 3 months to 1 year.

The **Visiting Faculty Program (VFP)** goal is to increase the research competitiveness of faculty members and students at post-secondary institutions of higher education historically underrepresented in the research community in order to expand the workforce that addresses DOE mission areas. Through direct collaboration with research staff at DOE host laboratories, VFP appointments provide an opportunity for faculty and students to develop skills applicable to programs at their home institutions; this helps increase the STEM workforce in DOE science mission areas at institutions historically under-represented within the DOE enterprise. Appointments are in the summer term for 10 weeks.

Albert Einstein Distinguished Educator Fellowship

The Albert Einstein Distinguished Educator Fellowship Act of 1994 charges the Department of Energy with administering a fellowship program for elementary and secondary school mathematics and science teachers that focuses on bringing teachers' real-world expertise to government to help inform federal STEM education goals and programs. Selected teachers spend eleven months in a Congressional office or a Federal agency. WDTS manages the Albert Einstein Distinguished Educator Fellowship (AEF) program for the Federal government. Fellows are supported by DOE and other Federal agencies. Typically, the Office of Science supports 6 Fellows each year; 4 are placed in Congressional offices and 2 are placed in the Office of Science. Other DOE offices, as well as the National Science Foundation, National Aeronautics and Space Administration, and National Oceanic and Atmospheric Administration also participate. The Fellows provide educational expertise, years of teaching experience, and personal insights to these offices to advance science, mathematics, and technology education programs.

National Science Bowl®

The DOE Office of Science National Science Bowl® (NSB) is a nationwide academic competition testing students' knowledge in all areas of mathematics and science, including energy. High school and middle school students are quizzed in a fast-paced, question-and-answer format. Since 1991, more than 225,000 students have participated in regional and national competitions.

The National Science Bowl® regional winning teams receive all-expenses paid trips to Washington D.C. to compete at the National Finals in late April. Competing teams are composed of four students, one alternate, and a teacher who serves as an advisor and coach. The Office of Science manages the National Science Bowl®, provides central management of 115 regional events, and sponsors the NSB finals competition.

In 2013, 5,000 middle school students from 725 schools and 9,090 high school students from 1,450 schools participated in the regional competitions, with 46 middle school and 69 high school teams (550 students) participating in the National Finals in Washington, D.C. More than 5,000 volunteers also participated in the local and national competitions.

In 2013, Alaska hosted regional middle and high school competitions for the first time, making the National Science Bowl® accessible to students in all fifty states.

The DOE National Science Bowl® is aligned with the CoSTEM Federal STEM Education 5-Year Strategic Plan priority investment area for STEM engagement.

Technology Development and On-Line Application

This activity modernizes on-line systems used to manage applications and review, data collection, and evaluation for WDTS programs. A project to develop, build, and launch new online application and program support systems is progressing to improve program management, execution, and evaluation by WDTS program staff and by DOE laboratory staff. The build schedule was met, enabling an inaugural launch in time for the 2013 summer internship programs. Since launch, the new online systems have enabled improved management of application and participant information and the collection and archiving of participant deliverables (such as research reports). An important component of the systems is the ability to support regular evidence-based evaluation of program performance and impact. A phased approach is being used to develop and build the systems. Following full completion of the systems supporting the 2014 SULI, CCI, and VFP Summer Term, the systems for the Albert Einstein Distinguished Educator Fellowship, the Graduate Student Research Program, and National Science Bowl® will be updated or developed.

Evaluation Studies

The Evaluation Studies activity supports work to assess whether WDTS programs meet established goals through the use of collection and analysis of data and other materials, including pre- and post-participation questionnaires, participant deliverables, notable outcomes (publications, presentations, patents, etc.), and longitudinal participant tracking.

Prior Committee of Visitors reviews found little evaluation of activities across WDTS but noted that the data collection and evaluation plans under development provided some innovative options for gathering workforce information and for tracking participants. In FY 2014, evaluation plans for each WDTS activity will be completed. Enhanced data analysis efforts, a Committee of Visitors review, and external peer review activities will begin in FY 2014 and continue into FY 2015.

Evaluation Studies is aligned with the GPRA Modernization Act of 2010, the President's management priorities,[a] and the 2008 Congressionally-mandated Academic Competitiveness Council initiative, which emphasized the need for federal programs (including STEM education programs) to demonstrate their effectiveness through rigorous evidence-based evaluation. WDTS works cooperatively with Office of Science programs, other DOE programs, and other federal agencies through CoSTEM to share best practices for STEM program evaluation to ensure the implementation of evaluation processes appropriate to the nature and scale of the program effort.

Outreach

WDTS engages in outreach activities, some in cooperation with other DOE program offices and select federal agencies, that seek to broaden participation in and enhance the student internships, the Graduate Student Research program, and the Visiting Faculty Program. The WDTS website[b] is the most widely used tool for prospective program participants to obtain information about WDTS. Website content has been optimized for mobile devices. Active outreach is also conducted via the web using live webinar virtual meetings to highlight the programs, their opportunities, and the WDTS internship experience, where a portfolio of live webinars delivered to broad stakeholder communities is being built, including access to recorded content. To improve access and user friendliness, the webinar solution offers robust voice over data, does not require software downloads aside from free Apps for mobile devices, and enables platform-independent access on the client side.

Laboratory Equipment Donation Program

The Laboratory Equipment Donation Program provides excess laboratory equipment to faculty at non-profit research institutions and post-secondary educational institutions. Through the Energy Asset Disposal System, DOE sites identify excess equipment and colleges and universities can then search for equipment of interest and apply via the website. The equipment is free, but the receiving institution pays for shipping costs.

[a] http://www.whitehouse.gov/administration/eop/ostp/nstc/committees/costem
[b] http://science.energy.gov/wdts/

Workforce Development for Teachers and Scientists
Funding ($K)

	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Activities at the DOE Laboratories					
Science Undergraduate Laboratory Internships	7,296	7,800	7,800	8,300	+500
Community College Internships	694	700	700	1,000	+300
Graduate Student Research Program (formerly Office of Science Graduate Fellowship)	2,986	10,700	10,700	2,500	-8,200
Visiting Faculty Program	1,310	1,300	1,300	1,700	+400
Total, Activities at the DOE Laboratories	**12,286**	**20,500**	**20,500**	**13,500**	**-7,000**
Albert Einstein Distinguished Educator Fellowship	**1,200**	**1,200**	**1,200**	**1,200**	**0**
National Science Bowl®	**2,800**	**2,800**	**2,800**	**2,900**	**+100**
Technology Development and On-Line Application	**550**	**550**	**550**	**750**	**+200**
Evaluation Studies	**300**	**600**	**600**	**600**	**0**
Outreach	**300**	**800**	**800**	**500**	**-300**
Laboratory Equipment Donation Program	**50**	**50**	**50**	**50**	**0**
Total, Workforce Development for Teachers and Scientists	**17,486**	**26,500**	**26,500**	**19,500**	**-7,000**

Program Accomplishments

Program Evaluation of the DOE Laboratory Activities. In FY 2013, WDTS executed the first of what will be triennial peer-reviews of activities at DOE laboratories (SULI, CCI, and VFP). The primary outcome of this subject matter expert review is the development and implementation of programmatic core requirements. These core requirements, which are aligned with evaluation logic models and related evaluation instruments, sets management standards for WDTS laboratory programs across the DOE laboratory complex.

Technology Development. In FY 2013, WDTS launched a new online management system for programmatic activities at DOE laboratories. In this system, applications, applicant reviews, applicant placements, participant deliverables, and participant feedback (in the form of pre- and post- participation questionnaires) are managed in one integrated web-based system, which uses an advanced information architecture for ease of use and a relational database structure for facile tracking, measurement, and reporting of data.

Workforce Development for Teachers and Scientists

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
Activities at the DOE Laboratories		
Science Undergraduate Laboratory Internships	*Science Undergraduate Laboratory Internships*	*Science Undergraduate Laboratory Internships*
SULI will support approximately 725 students. Consistent with Congressional direction in the FY 2014 Consolidated Appropriations Act, of the funds appropriated to WDTS, $500,000 is provided to support approximately 35 additional SULI students, accommodating increasing numbers of highly qualified applicants and DOE laboratory mentor interests in hosting additional semester term students.	SULI will support approximately 760 students, including support for an additional 35 fall and spring semester students.	Approximately 35 additional SULI students are supported to accommodate increasing numbers of highly qualified applicants and DOE laboratory mentor interests in hosting additional fall and spring semester students.
Community College Internships		
CCI will support approximately 70 students.	CCI will support approximately 90 students.	Approximately 20 additional CCI students are supported for newly available fall and spring semester terms, aligning CCI with SULI program and addressing DOE laboratory mentor interests in hosting CCI students for the longer, 16-week semester terms.
Graduate Student Research Program		
The SCGSR program will support approximately 100 graduate students for periods of 3 months to 1 year to conduct a part of their thesis research at DOE laboratories.	The SCGSR program will support approximately 130 graduate students for periods of 3 months to 1 year to conduct a part of their thesis research at DOE laboratories.	Approximately 30 additional awards will be provided in high priority research areas such as applied mathematics and computational sciences particle accelerator and detector science, actinide and nuclear chemistry, and neutron scattering science.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
Consistent with Congressional direction in the FY 2014 Consolidated Appropriations Act, of the funds appropriated to WDTS, $8,700,000 is provided for the Computational Sciences Graduate Fellowship (CSGF) program to fully-fund approximately 20 Fellows, to be overseen by the Office of Advanced Scientific Computing Research.		No funds are provided for the CSGF activity.
Visiting Faculty Program		
VFP will support approximately 50 faculty and 20 students.	VFP will support approximately 65 faculty and 30 students.	VFP supports approximately 15 additional faculty and 10 of their students, drawn from smaller colleges and universities, Historically Black Colleges and Universities, and Hispanic-Serving Institutions.
Albert Einstein Distinguished Educator Fellowship		
The FY 2014 request supports 6 Fellows.	The FY 2015 request supports 6 Fellows.	No change.
National Science Bowl®		
WDTS sponsors the finals competition and provides central management of 115 regional events, involving 14,000 students from all fifty states, the District of Columbia, Puerto Rico, and the U.S. Virgin Islands. National Finals: April 24-28, 2014.	WDTS sponsors the finals competition and provides central management of 115 regional events, involving 14,000 students from all fifty states, the District of Columbia, Puerto Rico, and the U.S. Virgin Islands. National Finals: April 23-27, 2015.	Funding is maintained to support a constant number of regional teams each year at the national finals competition.
Technology Development and On-line Application Systems		
Funding in FY 2014 completes the design, build, and implementation of online management systems for the SULI, CCI, VFP, and Albert Einstein Distinguished Educator Fellowship (AEF) programs, including evaluation. Funding also supports the development of the application system for the SCGSR program.	Funding in FY 2015 completes the design, build, and implementation of online management systems for the SCGSR, including the participant deliverables and evaluation components, and the National Science Bowl®. Funding also provides increased capacity for collecting data in support of evaluation studies.	Funding provides increased capacity for collecting data in support of evaluation studies.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
Evaluation Studies		
FY 2014 funding supports the implementation of evaluation plans for SULI, CCI, VFP, and AEF programs, including data archiving, curation, and analyses. It also supports a Committee of Visitors review of Federal program oversight and management. Consistent with Congressional direction in the FY 2014 Consolidated Appropriations Act, of the funds appropriated to WDTS, $300,000 is provided to support increased evaluation, data analysis, and external peer review of programs for effectiveness.	FY 2015 funding supports enhanced evaluation efforts initiated in FY 2014, and the implementation of an evaluation plan for the SCGSR, including data archiving, curation, and analyses.	No change.
Outreach		
Funding supports webinars and the launch of a WDTS website-based host DOE lab selection tool for stakeholders and a WDTS website landing page providing links to the portfolio of live and recorded webinars. Consistent with Congressional direction in the FY 2014 Consolidated Appropriations Act, of the funds appropriated to WDTS, $500,000 is provided for the QuarkNet program, to be overseen by the Office of High Energy Physics.	Funding supports development and deployment of a public web portal to track the inventory of STEM workforce internship and outreach activities and opportunities across the DOE laboratory complex. Enhanced outreach activities to the scientific community aimed at assessing the Office of Science mission-driven disciplinary workforce needs in the next 5 to 10 years are initiated.	Funding continues the ongoing activity. No funds are provided for the QuarkNet activity.
Laboratory Equipment Donation Program		
Funding continues the ongoing program.	Funding continues the ongoing program.	No change.

Science Laboratories Infrastructure

Overview

The Science Laboratories Infrastructure (SLI) program mission is to support scientific and technological innovation at the Office of Science (SC) laboratories by funding and sustaining mission-ready infrastructure and fostering safe and environmentally responsible operations. The program provides the infrastructure necessary to support world leadership by the SC national laboratories in the area of basic scientific research, now and in the future.

SLI's primary focus is on long-term modernization of SC laboratory infrastructure to ensure the mission readiness of SC laboratories. Through this program, SC is ensuring that its laboratories have state-of-the-art facilities and utilities that are flexible, reliable, and sustainable, with environmentally stable research space and high performance computing space needed to support scientific discovery. Facility designs ensure safe, collaborative, and interactive work environments and allow for the integration of basic and applied research and development. Projects in many cases include removal of aged and outdated facilities that are being replaced by new ones. New and renovated buildings and utilities include the latest temperature and humidity controls, clean power, and isolation from vibration and electromagnetic interference where needed.

In addition to the construction program, SLI's Infrastructure Support program provides SC stewardship responsibilities for the Oak Ridge Reservation and the Federal facilities in the City of Oak Ridge, Tennessee, and Payments in Lieu of Taxes (PILT) to local communities around the Argonne, Brookhaven, and Oak Ridge National Laboratories. The SLI program also provides funding to support facilities and infrastructure expenses for the Office of Scientific and Technical Information (OSTI), the Oak Ridge Institute for Science and Education (ORISE) at Oak Ridge, and the New Brunswick Laboratory (NBL) at the Argonne Site.

Highlights of the FY 2015 Budget Request

The SLI program has successfully completed nearly $400 million of infrastructure projects since FY 2006 when SC initiated a modernization effort to provide impactful infrastructure investments across the laboratory complex. Ongoing projects that will provide new laboratories, renovated facilities, and new utilities are proceeding towards on-time completion within budget. The FY 2015 Request provides final funding for one of these ongoing projects, the Science and User Support Building project at SLAC National Accelerator Laboratory (SLAC). Importantly, this budget also provides initial funding for the start of new projects. While significant improvements to SC infrastructure have been made, it is important to maintain a strong level of investment and continue making improvements across the complex. This budget request does that in accordance with best budgeting practices by fully funding one new project and funding full design of three additional projects. The Infrastructure and Operational Improvements project at the Princeton Plasma Physics Laboratory (PPPL) will modernize facilities that, today, do not adequately support ongoing plasma physics research. The Materials Design Laboratory project at Argonne National Laboratory (ANL), the Photon Science Laboratory Building project at SLAC National Accelerator Laboratory (SLAC), and the Integrative Genomics Building project at Lawrence Berkeley National Laboratory (LBNL) will provide new research facilities to further SC's core capabilities in materials science, photon science, and biosciences, respectively.

Beginning in FY 2015, SLI will also provide funding to support facilities and infrastructure activities for the ORISE facility at Oak Ridge which was previously supported through the Biological and Environmental Research (BER) program.

Science Laboratories Infrastructure
Funding ($K)

	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Infrastructure Support	**8,219**	**8,236**	**8,236**	**10,289**	**+2,053**
Construction					
Infrastructure and Operational Improvements at PPPL (15-SC-75)	0	0	0	25,000	+25,000
Materials Design Laboratory at ANL (15-SC-76)	0	0	0	7,000	+7,000
Photon Science Laboratory Building at SLAC (15-SC-77)	0	0	0	12,890	+12,890
Integrative Genomics Building at LBNL (15-SC-78)	0	0	0	12,090	+12,090
Utilities Upgrade at FNAL (13-SC-70)	0	34,900	34,900	0	-34,900
Utility Infrastructure Modernization at TJNAF (13-SC-71)	0	29,200	29,200	0	-29,200
Science and User Support Building at SLAC (12-SC-70)	14,512	25,482	25,482	11,920	-13,562
Research Support Building and Infrastructure Modernization at SLAC (10-SC-70)	36,382	0	0	0	0
Energy Sciences Building at ANL (10-SC-71)	32,030	0	0	0	0
Renovate Science Laboratories, Phase II, at BNL (10-SC-72)	14,530	0	0	0	0
Total, Construction	**97,454**	**89,582**	**89,582**	**68,900**	**-20,682**
Total, Science Laboratories Infrastructure	**105,673**	**97,818**	**97,818**	**79,189**	**-18,629**

Science Laboratories Infrastructure
Explanation of Major Changes ($K)

	FY 2015 vs. FY 2014 Enacted
Infrastructure Support: Funding increases to accommodate the transfer of funding for facilities and infrastructure support at the Oak Ridge Institute for Science and Education (ORISE) at Oak Ridge that was previously funded under the Biological and Environmental Research (BER) program. Funding also increases for additional facilities and infrastructure support at the New Brunswick Laboratory (NBL) at the Argonne site and to support reservation road repairs, critical maintenance needs, and other landlord responsibilities at the Oak Ridge Reservation and other DOE facilities in Oak Ridge. Funding for Payments in Lieu of Taxes to local communities around the Argonne and Brookhaven Laboratories increases slightly to accommodate the anticipated rate increase.	+2,053
Construction: Two projects received full funding in FY 2014. Final funding is provided at the planned level for the Science and User Support Building project at SLAC. Funding is also provided for four new project starts: the Infrastructure and Operational Improvements project at PPPL; the Materials Design Laboratory at ANL; the Photon Science Laboratory Building at SLAC; and the Integrative Genomics Building project at LBNL.	-20,682
Total, Science Laboratories Infrastructure	**-18,629**

Program Accomplishments

The *Interdisciplinary Science Building, Phase I at Brookhaven National Laboratory (BNL).* Construction of this new 87,700 square foot laboratory was completed within budget and ahead of schedule. Beneficial Occupancy was achieved on February 27, 2013 and the project achieved CD-4, Approve Project Completion, on April 8, 2013. The project earned Leadership in Energy and Environmental Design (LEED) Gold certification from the US Green Building Council. This completed project accommodates researchers from a wide variety of scientific disciplines. The new building contains 60 standard laboratories and four specialized labs with unique features for safely assembling and testing new lithium-ion batteries, exploring materials' electronic structure at the atomic scale, and fabricating new materials one atomic layer at a time.

The *Technology and Engineering Development Facility at Thomas Jefferson National Accelerator Facility (TJNAF).* Construction and renovation of this project was completed within budget and ahead of schedule. The project achieved CD-4A, Approve Start of Operations—New Construction, on March 22, 2012 upon completion of a 46,550 gross square foot addition to the Test Lab and completion of the new 74,600 square foot Technology and Engineering Development building to support engineering and fabrication functions. The project achieved CD-4B, Approve Start of Operations—Renovation, on September 27, 2013 upon complete renovation of the 90,000 gross square foot Test Lab building. The project earned LEED Gold certification for the new Technology and Engineering Development building and is expected to earn LEED Gold certification for the expanded and renovated Test Lab. This completed project transformed the lab campus and provides state-of-the-art facilities used to research, develop, and test superconducting accelerator technology critical to research in high-energy physics, nuclear physics, nuclear astrophysics, life sciences, and materials science.

The *Seismic Life-Safety, Modernization, and Replacement of General Purpose Buildings, Phase II at Lawrence Berkeley National Laboratory (LBNL).* CD-4A/B was achieved on September 25, 2012. This marked the completion of construction of Building 74. Seismic strengthening of Building 85 was substantially completed in July 2013. This project rectified seismic deficiencies and provides modern general purpose laboratory space used for research in energy and the environment.

The *Research Support Building and Infrastructure Modernization at SLAC National Accelerator Laboratory (SLAC).* Construction was completed on the Research Support Building (B052) on May 31, 2013. The project replaced more than a dozen 35-year old trailers and achieved LEED Gold certification. CD-3B, which includes the modernization of Building 41, was approved on June 28, 2013. This project will provide administrative and support space to integrate the accelerator science and technology communities across programmatic boundaries.

The *Energy Sciences Building at Argonne National Laboratory (ANL).* Construction of the new, main building was deemed substantially complete on June 30, 2013. Subcontracts to complete enhanced scope elements for the Materials for Energy Module and the Post Occupancy Fit Out were awarded in June 2013. The Energy Sciences Building at ANL is a sustainable interdisciplinary physical sciences laboratory designed to encourage collaboration between some of the country's leading scientists in chemistry, materials sciences, and condensed matter physics research. This 158,000 square foot facility will house over 240 researchers. It has linkages to the campus pathway system and connections to adjoining research and office buildings, creating a new consolidated campus for the energy sciences.

The *Science and User Support Building at SLAC National Accelerator Laboratory (SLAC).* Preliminary construction work, including demolition of the existing cafeteria, commenced in September 2013.

Science Laboratories Infrastructure
Infrastructure Support

Description

The Infrastructure Support subprogram provides SC stewardship responsibilities for the Oak Ridge Reservation and DOE facilities and provides infrastructure support for the OSTI and ORISE facilities in Oak Ridge, Tennessee. This subprogram also provides facilities infrastructure support for the New Brunswick Laboratory (NBL) at the Argonne site and provides Payments in Lieu of Taxes (PILT) to local communities around the Argonne, Brookhaven, and Oak Ridge National Laboratories.

Funding ($K)

	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Infrastructure Support					
Payments in Lieu of Taxes	1,385	1,385	1,385	1,412	+27
Facilities and Infrastructure	900	900	900	3,100	+2,200
Oak Ridge Landlord	5,934	5,951	5,951	5,777	-174
Total, Infrastructure Support	**8,219**	**8,236**	**8,236**	**10,289**	**+2,053**

<u>Payments in Lieu of Taxes</u>

The Department is authorized to provide discretionary payments to state and local government authorities for real property that is not subject to taxation because it is owned by the United States and operated by the Department. Under this authorization, PILT is provided to communities around the Argonne and Brookhaven National Laboratories to compensate for lost tax revenues for land removed from local tax rolls. PILT payments are negotiated between the Department and local governments based on land values and tax rates.

<u>Facilities and Infrastructure</u>

Funding within this activity is provided for support of general purpose infrastructure at NBL located on the site of the Argonne National Laboratory and at the OSTI and ORISE facilities in the city of Oak Ridge, Tennessee. Activities include general facilities and infrastructure support, General Plant Projects, and General Purpose Equipment.

<u>Oak Ridge Landlord</u>

Funding supports landlord responsibilities, including infrastructure for the 24,000–acre Oak Ridge Reservation and DOE facilities in the city of Oak Ridge, Tennessee. Activities include maintenance of roads, grounds, and other infrastructure; support and improvement of environmental protection, safety, and health; and Payments in Lieu of Taxes (PILT) to Oak Ridge communities. Landlord responsibilities exclude the Y-12 plant, ORNL, and the East Tennessee Technology Park.

Science Laboratories Infrastructure
Infrastructure Support

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Payments in Lieu of Taxes		
FY 2014 funding supports PILT payments to communities around the Argonne and Brookhaven National Laboratories.	The FY 2015 request provides funding for PILT payments to communities around the Argonne and Brookhaven National Laboratories.	Funding increases to accommodate increases in PILT requirements.
Facilities and Infrastructure		
Funding provided for general facilities and infrastructure support activities at NBL at Argonne.	The FY 2015 request provides funding for general facility and infrastructure support at NBL, OSTI, and ORISE.	Funding increases to accommodate additional support for facilities and infrastructure expenses at NBL. Funding also increases to support the transfer of general facility and infrastructure expenses for the ORISE facility at Oak Ridge which was previously funded through the SC BER program, and for OSTI which was previously included in the Oak Ridge Landlord line.
Oak Ridge Landlord		
FY 2014 funding supports activities to ensure continuity of operations and minimize interruptions due to infrastructure or other system failures and for facilities and infrastructure at OSTI.	The FY 2015 request provides funding for activities to ensure continuity of operations and minimize interruptions due to infrastructure or other system failures.	Funding decreases as support for general facility and infrastructure for OSTI is moved to the facilities and infrastructure line.

Science Laboratories Infrastructure
Construction

Description

The SLI Construction program funds line item projects to maintain and enhance the general purpose infrastructure at SC laboratories. SLI's infrastructure modernization construction projects are focused on the accomplishment of long-term science goals and strategies at each SC laboratory.

New Project Starts

<u>Infrastructure and Operational Improvements at PPPL (15-SC-75)</u>

The Infrastructure and Operational Improvements project will provide critical improvements to infrastructure and operations that support plasma and fusion-energy sciences research. Existing facilities and infrastructure at PPPL are marginally adequate to support cost effective research operations. For example, many researchers and engineers are housed in buildings that were originally built in the 1960s and include obsolete and inadequate enclosure, mechanical, electrical, and plumbing systems. This project will rectify the most significant site, building, utility and other infrastructure deficiencies as part of a comprehensive campus strategic facilities investment plan being developed for PPPL. Completion of this project will result in improved operational efficiency and modernized infrastructure that is essential necessary to support fusion energy sciences research.

The most recent DOE O 413.3B approved Critical Decision (CD) is CD-0, Approve Mission Need, which was approved on September 17, 2013. The estimated preliminary Total Project Cost (TPC) range for this project is $21,000,000 to $26,000,000. This cost range and project schedule will be further evaluated prior to CD-2.

Full funding is requested in FY 2015 which will cover all design and construction for this project.

<u>Materials Design Laboratory at ANL (15-SC-76)</u>

The Materials Design Laboratory project will support research in materials science in energy and a range of other fields. It will entail construction of a 90,000–150,000 gsf high–performance laboratory office building and adjacent building renovations. The existing research buildings at Argonne dedicated to this SC research mission are all more than 40 years old, some as old as 55 years. These structures require frequent repair, resulting in interruptions to research activities, and they are unable to meet modern standards for instruments requiring vibration, electromagnetic and/or thermal stability. Additional supporting functions such as utilities or site modifications may be included in the project, if necessary.

The most recent DOE O 413.3B approved Critical Decision (CD) is CD-0, Approve Mission Need, which was approved on August 27, 2010. The estimated preliminary TPC range for this project is $85,500,000 to $96,000,000. This cost range and project schedule will be further evaluated prior to CD-2.

FY 2015 funding will support full design of the project.

<u>Photon Science Laboratory Building at SLAC (15-SC-77)</u>

The Photon Science Laboratory Building project will provide centralized modern laboratory and office space to enable the development and expansion of SLAC's photon science programs. The Photon Science Laboratory Building will support the Linac Coherent Light Source; the Stanford Synchrotron Radiation Lightsource; the Photon Ultrafast Laser Science and Engineering Institute; and the Stanford Institute for Materials and Energy Sciences. Additional supporting functions such as utilities or site modifications may be included in the project, if necessary.

The most recent DOE O 413.3B approved Critical Decision (CD) is CD-0, Approve Mission Need, which was approved on May 11, 2011. The estimated preliminary Total Project Cost (TPC) range for this project is $49,500,000 to $57,000,000. This cost range and project schedule will be further evaluated prior to CD-2.

FY 2015 funding will support full design and initial construction work packages for this project.

Integrative Genomics Building at LBNL (15-SC-78)

Portions of the biosciences program at LBNL are located off-site, away from the main laboratory, and dispersed across multiple locations up to 20 miles apart. This project will relocate a significant fraction of the research and operations currently located in commercially leased space onto the main LBNL campus. Collocation of these programs will increase the synergy and efficiency of biosciences and other research at LBNL and will provide a state-of-the-art facility for biosciences research in a collaborative environment close to other key LBNL facilities and programs. Additional supporting functions such as utilities or site modifications may be included in the project, if necessary.

The most recent DOE O 413.3B approved Critical Decision (CD) is CD-0, Approve Mission Need, which was approved on September 17, 2013. The estimated preliminary Total Project Cost (TPC) range for this project is $71,500,000 to $91,500,000. This cost range and project schedule will be further evaluated prior to CD-2.

FY 2015 funding will support full design of the project.

On-Going Projects

Utilities Upgrade at FNAL (13-SC-70)

The reliability of Fermilab's current industrial cooling water and high-voltage electrical distribution systems is suffering due to increased pipe break and electrical failures. Also, current and future accelerator and experimental facilities at Fermilab will exhaust the capacity of the existing utility systems, and additional stresses to the system will exacerbate these problems. The Utilities Upgrade project will upgrade the laboratory's industrial cooling water and high voltage electrical system, which will mitigate environmental liability, improve reliability, and enable Fermilab to effectively perform high energy physics research.

This project received CD-1 approval on November 15, 2010.

This project is a new start in FY 2014 with full funding provided.

Utility Infrastructure Modernization at TJNAF (13-SC-71)

Existing utilities, including cryogenic, power distribution, cooling water, and communication systems at TNJAF continue to experience failures at increasing rates, which limits the laboratory's ability to support SC research programs. For example, the current cryogenic capacity is inadequate to support the needs in the Test Lab, which is the key facility for superconducting radio frequency development and production activities. This limits various superconducting radiofrequency research, fabrication, and testing supported by the SC Nuclear Physics (NP) program. In addition, the current power distribution system does not have the necessary redundancy to maintain operation of critical systems during power outages. The most critical shortfall is the inability to use an alternative power feed to restart the Central Helium Liquefier, a critical component to maintaining constant cryogenic temperatures in the accelerator cryomodules that prevent degradation of accelerator performance and costly repairs. These inadequacies reduce reliability and could jeopardize the laboratory's capability to support ongoing research supported by SC's Office of Nuclear Physics and High Energy Physics.

This project received CD-1 approval on October 14, 2010.

This project is a new start in FY 2014 with full funding provided.

Science and User Support Building at SLAC (12-SC-70)

With the success of the Linear Coherent Light Source (LCLS), SLAC is benefiting from a large influx of visitors and users and expects the demand to use SLAC's research facilities will continue to grow. The Science and User Support Building project will provide the expanded user space needed to ensure that the world-class research conducted at SLAC is supported by mission-ready facilities. This project will replace aging structures with a newly constructed building with an estimated area of 58,000–72,000 gsf that will house a centrally located user support hub; the visitor's center; a new cafeteria; office space needed to centralize SLAC communications, security, and laboratory administration; and a state-of-the-art auditorium, conference space, and associated site improvements. The Science and User Support Building will replace the aging structure that currently holds Panofsky Auditorium and the cafeteria built in 1962, the same year SLAC was founded. In order to meet the congressional mandates for replacement, the project plans to demolish the Panofsky Auditorium and the cafeteria (approximately 13,200 gsf) and use banked excess for the balance.

The most recent DOE 413.3B approved Critical Decision (CD) is CD-2/3, Approve Performance Baseline and Start of Construction, achieved on June 18, 2013.

FY 2015 funding will support the continuation of construction activities per the planned profile in the Preliminary Project Execution Plan. This project will receive final year funding in FY 2015.

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Infrastructure and Operational Improvements at PPPL (15-SC-75)		
	Funding requested in FY 2015 will support full design and construction of the project.	Funding is requested in FY 2015 to support the new start of this project.
Materials Design Laboratory at ANL (15-SC-76)		
	Funding requested in FY 2015 will support full design of the project.	Funding is requested in FY 2015 to support the new start of this project.
Photon Sciences Laboratory Building at SLAC (15-SC-77)		
	Funding requested in FY 2015 will support full design and the start of construction.	Funding is requested in FY 2015 to support the new start of this project.
Integrative Genomics Building at LBNL (15-SC-78)		
	Funding requested in FY 2015 will support full design of the project.	Funding is requested in FY 2015 to support the new start of this project.
Utilities Upgrade at FNAL (13-SC-70)		
Project is fully funded in FY 2014. Design and construction will commence this year.		Full funding is provided in FY 2014 for this project.
Utility Infrastructure Modernization at TJNAF (13-SC-71)		
Project is fully funded in FY 2014. Design and construction will commence this year.		Full funding is provided in FY 2014 for this project.
Science and User Support Building at SLAC (12-SC-70)		
Funding supports construction activities which will continue in FY 2014.	Funding in FY 2015 will support the continuation of construction activities. FY 2015 is the final year of funding for this project.	Funding requested in FY 2015 will complete funding for construction activities.

Science Laboratories Infrastructure
Capital Summary ($K)

	Total	Prior Years	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Capital Operating Expenses							
General plant projects	n/a	n/a	300	300	800	800	+500

Construction Projects Summary ($K)

	Total Project Cost(TPC)	Prior Years	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Infrastructure and Operational Improvements at PPPL (15-SC-75)							
TEC	25,000[a]	0	0	0	0	25,000	+25,000
OPC[b]	1,000	0	0	1,000	1,000	0	-1,000
TPC	26,000[a]	0	0	1,000	1,000	25,000	+24,000
Materials Design Laboratory at ANL (15-SC-76)							
TEC	95,000[a]	0	0	0	0	7,000	+7,000
OPC[b]	882	882	0	0	0	0	0
TPC	95,882[a]	882	0	0	0	7,000	+7,000

[a] This project has not received CD-2 approval; therefore, preliminary cost estimates are shown for TEC and TPC.
[b] Other Project Costs shown are funded through laboratory overhead.

	Total Project Cost(TPC)	Prior Years	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Photon Sciences Laboratory Building at SLAC (15-SC-77)							
TEC	55,000[a]	0	0	0	0	12,890	+12,890
OPC[b]	2,000	1,341	0	0	0	0	0
TPC	57,000[a]	1,341	0	0	0	12,890	+12,890
Integrative Genomics Building at LBNL (15-SC-78)							
TEC	90,000[a]	0	0	0	0	12,090	+12,090
OPC[b]	1,500	0	0	1,500	1,500	0	-1,500
TPC	91,500[a]	0	0	1,500	1,500	12,090	+10,590
Utilities Upgrade at FNAL (13-SC-70)							
TEC	34,900[a]	0	0	34,900	34,900	0	-34,900
OPC[b]	1,100	1,100	0	0	0	0	0
TPC	36,000[a]	1,100	0	34,900	34,900	0	-34,900
Utility Infrastructure Modernization at TJNAF (13-SC-71)							
TEC	29,200[a]	0	0	29,200	29,200	0	-29,200
OPC[b]	700	700	0	0	0	0	0
TPC	29,900[a]	700	0	29,200	29,200	0	-29,200
Science & User Support Building at SLAC (12-SC-70)							
TEC	64,000[a]	0	14,512	25,482	25,482	11,920	-13,562
OPC[b]	1,000	562	0	238	238	200	-38
TPC	65,000[a]	562	14,512	25,720	25,720	12,120	-13,600

[a] This project has not received CD-2 approval; therefore, preliminary cost estimates are shown for TEC and TPC.

[b] Other Project Costs shown are funded through laboratory overhead.

	Total Project Cost(TPC)	Prior Years	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Research Support Building and Infrastructure Modernization at SLAC (10-SC-70)							
TEC	96,000	47,594	36,382	0	0	0	0
OPC[a]	1,400	705	216	230	230	0	-230
TPC	97,400	48,299	36,598	230	230	0	-230
Energy Sciences Building at ANL (10-SC-71)							
TEC	95,000	22,970	32,030	0	0	0	0
OPC[a]	956	956	0	0	0	0	0
TPC	95,956	23,926	32,030	0	0	0	0
Renovate Science Laboratories, Phase II, at BNL (10-SC-72)							
TEC	50,000	19,970	14,530	0	0	0	0
OPC[a]	800	800	0	0	0	0	0
TPC	50,800	20,770	14,530	0	0	0	0
Total, Construction							
TEC	n/a	n/a	97,454	89,582	89,582	68,900	-20,682
OPC[a]	n/a	n/a	216	2,968	2,968	200	-2,768
TPC	n/a	n/a	97,670	92,550	92,550	69,100	-23,450

[a] Other Project Costs shown are funded through laboratory overhead.

15-SC-75, Infrastructure and Operational Improvements
Princeton Plasma Physics Laboratory (PPPL), Princeton, New Jersey
Project is for Design and Construction

1. Significant Changes

The most recent DOE O 413.3B approved Critical Decision (CD) is CD-0, Approve Mission Need, which was approved on September 17, 2013. The preliminary Total Estimated Cost (TEC) range for this project is $20,000,000 to $25,000,000. The preliminary Total Project Cost (TPC) range is $21,000,000 to $26,000,000.

A Federal Project Director with a certification level 2 has been assigned to this project.

This Project Data Sheet (PDS) includes a new start for the budget year.

This PDS is new.

2. Design, Construction, and D&D Schedule

(fiscal quarter or date)

	CD-0	CD-1	Design Complete	CD-2	CD-3	CD-4	D&D Start	D&D Complete
FY 2015	09/17/2013	4Q FY 2014	4Q FY 2015	4Q FY 2015[a]	4Q FY 2015[a]	4Q FY 2019[a]	4Q FY 2015[a]	4Q FY 2019[a]

CD-0 – Approve Mission Need
CD-1 – Approve Alternative Selection and Cost Range
CD-2 – Approve Performance Baseline
CD-3 – Approve Start of Construction
CD-4 – Approve Project Closeout
D&D Start – Start of Demolition & Decontamination (D&D) work
D&D Complete – Completion of D&D work

3. Baseline and Validation Status

(dollars in thousands)

	TEC, Design	TEC, Construction	TEC, Total	OPC[b] Except D&D	OPC, D&D	OPC, Total	TPC
FY 2015	2,500	22,500[c]	25,000[c]	1,000	0	1,000	26,000[c]

4. Project Description, Justification, and Scope

Mission Need

Princeton Plasma Physics Laboratory (PPPL) has a dual mission to enable fusion energy research for the Office of Science and to lead discoveries across the broad frontier of plasma science and technology. PPPL's major collaborative facility, the National Spherical Torus Experiment (NSTX), is exploring the potential of a spherical torus plasma configuration for fusion

[a] This project is pre-CD-2, and schedule estimates are preliminary. Construction funds will not be executed without appropriate CD approvals.
[b] Other project costs (OPC) are funded through laboratory overhead.
[c] This project has not received CD-2 approval; funding estimates are consistent with the high end of the preliminary cost ranges. The preliminary TEC range for this project is $20,000,000 to $25,000,000. The preliminary TPC range for this project is $21,000,000 to $26,000,000.

energy and developing solutions for the plasma-material interface. PPPL research also contributes to plasma science and applications generally, in areas such as plasma-based mass filters for nuclear waste remediation, plasma-based nanotechnology for improved production of nanomaterials, plasma rocket thrusters for fine positioning of satellites, and development of new techniques for short-pulse and intense lasers.

While the size of the PPPL site is adequate for current and anticipated future needs, the L-Wing and the Motor Generator buildings are both inadequate to support cost effective research operations. Researchers and engineers are housed in buildings that were originally built in the 1960s which include obsolete and inadequate enclosure, mechanical, electrical, and plumbing systems such as failed electrical circuits, leaking windows and walls, rotting wall structures, and lack of insulation. This project will rectify the most significant site, building, utility, and other infrastructure deficiencies as part of a comprehensive campus strategic facilities investment plan being developed for PPPL. Completion of this project will result in improved operational efficiency and modernized infrastructure that is essential necessary to support fusion energy sciences research.

Scope and Justification (15-SC-75, Infrastructure and Operational Improvements Project)

If these capability gaps are not closed in the near term, PPPL will continue to struggle with increased operating costs and reduced efficiency as a result of the serious infrastructure quality issues that have accrued over the years. If these gaps are not closed in the long term, PPPL cannot continue to operate as a safe, operationally sound national laboratory. Closing these capability gaps will decrease utility costs, increase energy efficiency, reduce greenhouse gas emissions and help achieve DOE sustainability goals. More efficient use of space will increase workflow efficiencies and collaboration between researchers and engineers, and as a result, will better support the research being conducted. The scope of the project may include selective modernization of the existing L-Wing or Motor Generator Building, or both. Obsolete and inadequate architectural, structural, mechanical, electrical, and/or plumbing systems will be replaced. Additional supporting functions such as utilities or site modifications may be included in the project, if they are deemed necessary.

This project has not yet received CD-1 approval; therefore key performance parameters (KPPs) are to be determined. The table below outlines preliminary KPPs.

Description	Threshold Value (Minimum)	Objective Value (Maximum)
Rehabilitation/Renovation	15,000 gross square feet	40,000 gross square feet

This mission need may be met with multiple project alternatives, such as renovations to improve the infrastructure and operations, which will be analyzed in the conceptual design phase to ensure the proposed strategy is the most cost-effective method of meeting the identified mission need.

Other Project Costs, funded through laboratory overhead, will be used to complete the conceptual design documents. FY 2015 funds will be used to complete the preliminary and final designs for all aspects of the project, to start and complete construction work, and for project management and support activities. Fully funding this project in FY 2015 is consistent with DOE project management policy and will mitigate procurement risks.

The project will be conducted in accordance with the project management requirements in DOE O 413.3B, Program and Project Management for the Acquisition of Capital Assets, and all appropriate project management requirements will be met.

5. Financial Schedule

(dollars in thousands)

	Appropriations	Obligations	Costs
Total Estimated Cost (TEC)			
PED			
FY 2015	2,500	2,500	2,500
Construction			
FY 2015	22,500	22,500	6,000
FY 2016	0	0	11,500
FY 2017	0	0	3,500
FY 2018	0	0	1,500
Total, Construction	22,500	22,500	22,500
TEC			
FY 2015	25,000	25,000	8,500
FY 2016	0	0	11,500
FY 2017	0	0	3,500
FY 2018	0	0	1,500
Total, TEC[a]	25,000	25,000	25,000
Other Project Cost (OPC)[b]			
OPC except D&D			
FY 2014	800	800	800
FY 2015	200	200	200
Total, OPC	1,000	1,000	1,000

[a] This project has not received CD-2 approval; funding estimates are consistent with the high end of the preliminary cost ranges. The preliminary TEC range for this project is $20,000,000 to $25,000,000. The preliminary TPC range for this project is $21,000,000 to $26,000,000.

[b] Other Project Costs are funded through laboratory overhead.

(dollars in thousands)

	Appropriations	Obligations	Costs
Total Project Cost (TPC)			
FY 2014	800	800	800
FY 2015	25,200	25,200	8,700
FY 2016	0	0	11,500
FY 2017	0	0	3,500
FY 2018	0	0	1,500
Total, TPC[a]	26,000	26,000	26,000

6. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design			
Design	2,000	N/A	N/A
Contingency	500	N/A	N/A
Total, Design	2,500	N/A	N/A
Construction			
Construction	18,000	N/A	N/A
Contingency	4,500	N/A	N/A
Total, Construction	22,500	N/A	N/A
Total, TEC[a]	25,000	N/A	N/A
Contingency, TEC	5,000	N/A	N/A

[a] This project has not received CD-2 approval; funding estimates are consistent with the high end of the preliminary cost ranges. The preliminary TEC range for this project is $20,000,000 to $25,000,000. The preliminary TPC range for this project is $21,000,000 to $26,000,000.

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Other Project Cost (OPC)[a]			
OPC except D&D			
Other OPC	800	N/A	N/A
Contingency	200	N/A	N/A
Total, OPC	1,000	N/A	N/A
Contingency, OPC	200	N/A	N/A
Total, TPC[b]	26,000	N/A	N/A
Total, Contingency	5,200	N/A	N/A

7. Funding Profile History

(dollars in thousands)

Request Year		FY 2014	FY 2015	Total
FY 2015	TEC	0	25,000	25,000[b]
	OPC[a]	1,000	0	1,000
	TPC	1,000	25,000	26,000[b]

8. Related Operations and Maintenance Funding Requirements

Start of Construction or Beneficial Occupancy (fiscal quarter and year)	1Q FY 2019
Expected Useful Life (number of years)	40
Expected Future Start of D&D of this capital asset (fiscal quarter and year)	1Q FY 2059

[a] Other Project Costs (OPC) are funded through laboratory overhead.

[b] This project has not received CD-2 approval; funding estimates are consistent with the high end of the preliminary cost ranges. The preliminary TEC range for this project is $20,000,000 to $25,000,000. The preliminary TPC range for this project is $21,000,000 to $26,000,000.

(Related Funding requirements)

	(dollars in thousands)			
	Annual Costs		Life Cycle Costs	
	Current Total Estimate	Previous Total Estimate	Current Total Estimate	Previous Total Estimate
Operations	$300	N/A	$12,000	N/A
Maintenance	$600	N/A	$24,000	N/A
Total, Operations & Maintenance[a]	$900	N/A	$36,000	N/A

9. Required D&D Information

Not Applicable

10. Acquisition Approach

Acquisition for this project will be performed by the PPPL Management and Operating (M&O) contractor, Princeton University. The M&O contractor is responsible for awarding and managing all subcontracts related to this project. The M&O contractor will evaluate various acquisition alternatives and project delivery methods prior to achieving CD-1. Potential acquisition and project delivery methods include, but are not limited to, firm fixed price contracts for design-bid-build and design-build. The M&O contractor will also evaluate potential benefits of using a single or multiple contracts to procure materials, equipment, construction, commissioning, and other project scope elements. Project performance metrics for PPPL will be included in the M&O contractor's annual performance and evaluation measurement plan.

[a] This project does not have CD-2 approval; the O&M funding requirements have been based on parametric comparison of similar PPPL buildings.

15-SC-76 Materials Design Laboratory
Argonne National Laboratory (ANL), Argonne, IL
Project is for Design and Construction

1. Significant Changes

The most recent DOE O 413.3B approved Critical Decision (CD) is CD-0, *Approve Mission Need*, which was approved on August 27, 2010. The preliminary Total Estimated Cost (TEC) range for this project is $84,500,000 to $95,000,000. The estimated preliminary Total Project Cost (TPC) range for this project is $85,500,000 to $96,000,000.

A Federal Project Director with the appropriate certification level will be assigned to this project.

This Project Data Sheet (PDS) does include a new start for the budget year.

This PDS is new.

2. Design, Construction, and D&D Schedule

(fiscal quarter or date)

	CD-0	CD-1	Design Complete	CD-2	CD-3	CD-4
FY 2015	08/27/2010	4Q FY 2014	4Q FY 2016	4Q FY 2015[a]	3Q FY 2016[a]	2Q FY 2020[a]

CD-0 – Approve Mission Need
CD-1 – Approve Alternative Selection and Cost Range
CD-2 – Approve Performance Baseline
CD-3 – Approve Start of Construction
CD-4 – Approve Start of Operations or Project Closeout

3. Baseline and Validation Status

(dollars in thousands)

	TEC, Design	TEC, Construction	TEC, Total	OPC[b] Except D&D	OPC, D&D	OPC, Total	TPC
FY 2015	7,000	88,000[c]	95,000[c]	1,000	N/A	1,000	96,000[c]

4. Project Description, Scope, and Justification

Mission Need

Office of Science (SC) research at Argonne National Laboratory (ANL) supports the development of revolutionary materials and novel molecular processes to transform global energy production and storage. The Materials Design Laboratory will provide the modern collaborative scientific environment critical for this initiative to thrive and will focus on four themes central to implementing the Materials for Energy strategy:

- Frontiers of materials and molecular synthesis, and fabrication of devices;
- Interfacial engineering for energy applications;

[a] This project is pre-CD-2 and schedule estimates are preliminary.
[b] Other Project Costs (OPC) are funded through laboratory overhead.
[c] This project has not received CD-2 approval; funding estimates are consistent with the high end of the preliminary cost ranges. The preliminary TEC range for this project is $84,500,000 to $95,000,000. The preliminary TPC range for this project is $85,500,000 to $96,000,000.

- Materials under extreme conditions; and
- In situ characterization and modeling.

Ongoing SC research at ANL requires flexible and sustainable laboratory and office space needed to support scientific theory/simulation, materials discovery, characterization, and application of new energy-related materials and processes. Efficient, high-accuracy heating, ventilation, and air conditioning (HVAC) systems will be installed to support cutting edge research and the operation of sensitive instrumentation. Comparable space is not available at ANL.

Scope and Justification (15-SC-76, Material Design Laboratory at ANL)

The Materials Design Laboratory is proposed to enable Materials for Energy research capability by constructing a 90,000 to 150,000 square foot high performance laboratory building. The existing research buildings at Argonne dedicated to the SC energy research mission are all greater than 40 years old, some as much as 55 years old. They require constant repair, frequently compromising scientific research and are unable to meet modern standards for high-resolution scientific apparatus requiring vibration, electromagnetic and thermal stability. Additional supporting functions such as utilities or site modifications may be included in the project, if they are deemed necessary. Alternatives will be evaluated prior to CD-1 during acquisition strategy development. Project Key Performance parameters are as follows:

Description	Threshold Value (Minimum)	Objective Value (Maximum)
Multistory Laboratory Building	90,000 gross square feet	150,000 gross square feet

FY 2015 funds will be used for preliminary and final design, project management, and support activities.

The project will be conducted in accordance with the project management requirements in DOE O 413.3B, Program and Project Management for the Acquisition of Capital Assets, and all appropriate project management requirements have been met.

5. Financial Schedule

(dollars in thousands)

	Appropriations	Obligations	Costs
Total Estimated Cost (TEC)			
Design			
FY 2015	7,000	7,000	6,000
FY 2016	0	0	1,000
Total, Design	7,000	7,000	7,000
Construction			
FY 2016	24,003	24,003	19,000
FY 2017	36,466	36,466	25,000
FY 2018	27,531	27,531	36,000
FY 2019	0	0	8,000
Total, Construction	88,000	88,000	88,000

(dollars in thousands)

	Appropriations	Obligations	Costs
TEC			
FY 2015	7,000	7,000	6,000
FY 2016	24,003	24,003	20,000
FY 2017	36,466	36,466	25,000
FY 2018	27,531	27,531	36,000
FY 2019	0	0	8,000
Total, TEC[a]	95,000	95,000	95,000
Other Project Cost (OPC)[b]			
OPC except D&D			
FY 2010	412	412	412
FY 2011	-30[c]	-30[c]	-30[c]
FY 2014	500	500	500
FY 2018	118	118	118
Total, OPC except D&D	1,000	1,000	1,000
Total Project Cost (TPC)			
FY 2010	412	412	412
FY 2011	-30	-30	-30
FY 2014	500	500	500
FY 2015	7,000	7,000	6,000
FY 2016	24,003	24,003	20,000
FY 2017	36,466	36,466	25,000
FY 2018	27,649	27,649	36,118
FY 2019	0	0	8,000
Total, TPC[a]	96,000	96,000	96,000

[a] This project has not received CD-2 approval; funding estimates are consistent with the high end of the preliminary cost ranges. The preliminary TEC range for this project is $84,500,000 to $95,000,000. The preliminary TPC range for this project is $85,500,000 to $96,000,000.

[b] Other Project Costs (OPC) are funded through laboratory overhead.

[c] OPC Funding was adjusted in FY 2011 to reflect FY 2010 actuals ($382,000 for OPC funding in FY 2010).

6. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design			
Design	5,900	N/A	N/A
Contingency	1,100	N/A	N/A
Total, Design	7,000	N/A	N/A
Construction			
Construction	72,000	N/A	N/A
Contingency	16,000	N/A	N/A
Total, Construction	88,000	N/A	N/A
Total, TEC[a]	95,000	N/A	N/A
Contingency, TEC	17,100	N/A	N/A
Other Project Cost (OPC)[b]			
OPC except D&D			
Conceptual Planning	382	N/A	N/A
Conceptual Design	400	N/A	N/A
Contingency	218	N/A	N/A
Total, OPC	1,000	N/A	N/A
Contingency, OPC	218	N/A	N/A
Total, TPC[a]	96,000	N/A	N/A
Total, Contingency	17,318	N/A	N/A

[a] This project has not received CD-2 approval; funding estimates are consistent with the high end of the preliminary cost ranges. The preliminary TEC range for this project is $84,500,000 to $95,000,000. The preliminary TPC range for this project is $85,500,000 to $96,000,000.

[b] Other Project Costs (OPC) are funded through laboratory overhead.

7. Schedule of Appropriation Requests

Request Year		(dollars in thousands) Prior Years	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	Total
FY 2015	TEC	0	0	7,000	24,003	36,466	27,531	95,000[a]
	OPC[b]	382	500	0	0	0	118	1,000
	TPC	382	500	7,000	24,003	36,466	27,649	96,000[a]

8. Related Operations and Maintenance Funding Requirements

Not Applicable

9. Required D&D Information

The square footage of the new proposed construction will be offset with banked area from another DOE facility prior to CD-1. This replacement facility must be constructed prior to any demolition. The new facility will be designed to support integration of multiple science disciplines and programs that will be relocated from various buildings on site, and will not simply replace a single facility. Once all moves into the new facility are complete, open spaces will be consolidated to allow demolition of an outdated, energy-inefficient facility. This project does not involve any decommissioning, decontamination or demolition.

10. Acquisition Approach

The M&O Contractor, Argonne University of Chicago, LLC, will have prime responsibility for oversight of both the design and construction subcontracts. The M&O Contractor has extensive experience in the management and oversight of contracts of equal or greater complexity than the proposed Material Design Laboratory. The M&O Contractor's project management, construction management, and ES&H management systems have all proven to be effective in the execution and control of projects of similar scale and magnitude.

Various acquisition alternatives will be considered for this project. After considering all alternatives in relation to the schedule, size, and risk, the use of a tailored Design-Bid-Build approach with design by an Architectural/Engineering firm, construction management (CM) services through the industrial partnership, and construction by a General Contractor (GC), all led by the M&O Contractor integrated project team, may provide the best construction delivery method and the lowest risk. In addition, the M&O Contractor's standard procurement practice is to use firm fixed-priced contracts and the M&O Contractor has extensive experience in project management, construction management, and environmental, safety, and health (ES&H) management systems in the acquisition of scientific facilities.

[a] This project has not received CD-2 approval; funding estimates are consistent with the high end of the preliminary cost ranges. The preliminary TEC range for this project is $84,500,000 to $95,000,000. The preliminary TPC range for this project is $85,500,000 to $96,000,000.

[b] Other Project Costs (OPC) are funded through laboratory overhead.

15-SC-77 Photon Science Laboratory Building
SLAC National Accelerator Laboratory, Menlo Park, California
Project is for Design and Construction

1. Significant Changes

The most recent DOE O 413.3B approved Critical Decision (CD) is CD-0, *Approve Mission Need*, which was approved April 18, 2011. The preliminary Total Estimated Cost (TEC) range for this project is $47,500,000 to $55,000,000. The estimated preliminary Total Project Cost (TPC) range for this project is $49,500,000 to $57,000,000.

A Federal Project Director with the appropriate certification level will be assigned to this project.

This Project Data Sheet (PDS) does include a new start for the budget year.

This PDS is new.

2. Design, Construction, and D&D Schedule

(fiscal quarter or date)

	CD-0	CD-1	Design Complete	CD-2/3A	CD-3B	CD-4
FY 2015	4/18/2011	1Q FY 2015	1Q FY 2017	4Q FY 2015[a]	3Q FY 2016[a]	1Q FY 2019[a]

CD-0 – Approve Mission Need
CD-1 – Approve Alternative Selection and Cost Range
CD-2/3A – Approve Performance Baseline and Early Construction Activities
CD-3B – Approve Start of Balance of Construction Activities
CD-4 – Approve Start of Operations or Project Closeout

3. Baseline and Validation Status

(dollars in thousands)

	TEC, Design	TEC, Construction	TEC, Total	OPC[b] Except D&D	OPC, D&D	OPC, Total	TPC
FY 2015	4,000	51,000[c]	55,000	2,000	0	2,000[c]	57,000[c]

4. Project Description, Justification, and Scope

Mission Need

SLAC is an Office of Science (SC) laboratory that supports a large national and international community of scientific users performing cutting-edge research in support of the Department of Energy mission. SLAC was built in 1962 to perform research in accelerator-based particle physics. Expansion and upgrade of the Stanford Synchrotron Radiation Lightsource (SSRL) and the Linac Coherent Light Source (LCLS) located at SLAC are producing rapid increases to photon science facility use, thereby increasing the need for space to accommodate the new and expanded research program.

[a] This project is pre-CD-2 and schedule estimates are preliminary.
[b] Other Project Costs (OPC) are funded through laboratory overhead.
[c] This project has not received CD-2 approval; funding estimates are consistent with the high end of the preliminary cost ranges. The preliminary TEC cost range for this project is $47,500,000 to $55,000,000. The preliminary TPC cost range for this project is $49,500,000 to $57,000,000.

Scope and Justification (Photon Science Laboratory Building at SLAC)

Construction of the Photon Science Laboratory Building is needed to provide centralized modern laboratory and/or office space with the necessary performance capabilities and accommodate growth in the existing photon science program. The Photon Science Laboratory Building would leverage the capabilities of two of the country's world-class light sources, Linac Coherent Light Source (LCLS) and Stanford Synchrotron Radiation Laboratory (SSRL), as well as the Photon Ultrafast Laser Science and Engineering (PULSE) and Stanford Institute for Materials and Energy Sciences (SIMES) photon institutes. Without modern facilities suitable for collocated and coordinated functionality, the laboratory's ability to successfully address and deliver on the long term strategic mission of the laboratory will be limited.

To close the mission capability gap and ensure that the world-class research conducted by SLAC scientific staff and users is supported by modern, mission-ready facilities, an additional 50,000 to 75,000 gross square feet (gsf) of modern laboratory space is needed above and beyond existing space to accommodate a range of simulation, theory and modeling, synthetic and characterization capabilities, while also supporting research collaborations with outside scientists engaged with SLAC's LCLS and SSRL user facilities. Additional supporting functions such as utilities or site modifications may be included in the project, if they are deemed necessary.

Description	Threshold Value (Minimum)	Objective Value (Maximum)
Multistory Office Building	50,000 gross square feet	75,000 gross square feet

FY 2015 funds will be used for preliminary and final design, and project management and support activities.

The project will be conducted in accordance with the project management requirements in DOE Order 413.3B, Program and Project Management for the Acquisition of Capital Assets.

5. Financial Schedule

(dollars in thousands)

	Appropriations	Obligations	Costs
Total Estimated Cost (TEC)			
Design			
FY 2015	4,000	4,000	1,000
FY 2016	0	0	2,500
FY 2017	0	0	500
Total, Design	4,000	4,000	4,000
Construction			
FY 2015	8,890	8,890	5,500
FY 2016	25,770	25,770	16,000
FY 2017	16,340	16,340	21,500
FY 2018	0	0	8,000
Total, Construction	51,000	51,000	51,000

(dollars in thousands)

	Appropriations	Obligations	Costs
TEC			
FY 2015	12,890	12,890	6,500
FY 2016	25,770	25,770	18,500
FY 2017	16,340	16,340	22,000
FY 2018	0	0	8,000
Total, TEC[a]	55,000	55,000	55,000
Other Project Cost (OPC)[b]			
OPC except D&D			
FY 2014	1,341	1,341	1,341
FY 2015	0	0	0
FY 2016	200	200	200
FY 2017	459	459	459
Total, OPC except D&D	2,000	2,000	2,000
Total Project Cost (TPC)			
FY 2014	1,341	1,341	1,341
FY 2015	12,890	12,890	6,500
FY 2016	25,970	25,970	18,700
FY 2017	16,799	16,799	22,459
FY 2018	0	0	8,000
Total, TPC[a]	57,000	57,000	57,000

[a] This project has not received CD-2 approval; funding estimates are consistent with the high end of the preliminary cost ranges. The preliminary TEC cost range for this project is $47,500,000 to $55,000,000. The preliminary TPC cost range for this project is $49,500,000 to $57,000,000.
[b] Other Project Costs are funded through laboratory overhead.

6. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design			
Design	3,300	N/A	N/A
Contingency	700	N/A	N/A
Total, Design	4,000	N/A	N/A
Construction			
Construction	42,500	N/A	N/A
Contingency	8,500	N/A	N/A
Total, Construction	51,000	N/A	N/A
Total, TEC[a]	55,000	N/A	N/A
Contingency, TEC	9,200	N/A	N/A
Other Project Cost (OPC)[b]			
OPC except D&D			
Other OPC	1,200	N/A	N/A
Start-Up	450	N/A	N/A
Contingency	350	N/A	N/A
Total, OPC	2,000	N/A	N/A
Contingency, OPC	350	N/A	N/A
Total, TPC[a]	57,000	N/A	N/A
Total, Contingency	9,550	N/A	N/A

[a] This project has not received CD-2 approval; funding estimates are consistent with the high end of the preliminary cost ranges. The preliminary TEC cost range for this project is $47,500,000 to $55,000,000. The preliminary TPC cost range for this project is $49,500,000 to $57,000,000.
[b] Other Project Costs (OPC) are funded through laboratory overhead.

7. Funding Profile History

(dollars in thousands)

Request Year		FY 2014	FY 2015	FY 2016	FY 2017	Total
FY 2015	TEC	0	12,890	25,770	16,340	55,000[a]
	OPC[b]	1,341	0	200	459	2,000
	TPC	1,341	12,890	25,970	16,799	57,000[a]

8. Related Operations and Maintenance Funding Requirements

Start of Construction or Beneficial Occupancy (fiscal quarter and year)	4Q FY 2018
Expected Useful Life (number of years)	50
Expected Future Start of D&D of this capital asset (fiscal quarter and year)	4Q FY 2068

(Related Funding requirements)

(dollars in thousands)

	Annual Costs		Life Cycle Costs	
	Current Total Estimate	Previous Total Estimate	Current Total Estimate	Previous Total Estimate
Operations	$240	N/A	$12,000	N/A
Maintenance	$460	N/A	$23,000	N/A
Total, Operations & Maintenance[c]	$700	N/A	$35,000	N/A

9. Required D&D Information

In order to meet the congressional mandates for one-for-one replacement, the project plans to use SC's banked excess space at SLAC to offset the full area of new construction.

	Square Feet
Area of new construction	Approximately 25,000
Area of existing facility(ies) being replaced and D&D'd by this project	0
Area of other D&D outside the project	0
Area of any additional D&D space to meet the "one-for-one" requirement taken from the banked area.	Approximately 25,000

[a] This project has not received CD-2 approval; funding estimates are consistent with the high end of the preliminary cost ranges. The preliminary TEC cost range for this project is $47,500,000 to $55,000,000. The preliminary TPC cost range for this project is $49,500,000 to $57,000,000.
[b] Other Project Costs (OPC) are funded through laboratory overhead.
[c] This project does not have CD-2 approval; the O&M funding requirements have been based on parametric comparison of similar Argonne new building construction.

10. Acquisition Approach

Acquisition for this project will be performed by the SLAC Management and Operating (M&O) contractor, Stanford University. The M&O contractor is responsible for awarding and managing all subcontracts related to this project. The M&O contractor will evaluate various acquisition alternatives and project delivery methods prior to achieving CD-1. Potential acquisition and project delivery methods include, but are not limited to, firm fixed price contracts for design-bid-build and design-build. The M&O contractor will also evaluate potential benefits of using a single or multiple contracts to procure materials, equipment, construction, commissioning and other project scope elements. Project performance metrics for SLAC will be included in the M&O contractor's annual performance and evaluation measurement plan.

15-SC-78, Integrative Genomics Building
Lawrence Berkeley National Laboratory (LBNL), Berkeley, California
Project is for Design and Construction

1. Significant Changes

The first DOE O 413.3B Critical Decision (CD) is CD-0, *Approve Mission Need,* was approved on September 17, 2013. The preliminary Total Estimated Cost (TEC) range for this project is $70,000,000 to $90,000,000. The preliminary Total Project Cost (TPC) range for this project is $71,500,000 to $91,500,000.

A Federal Project Director with a certification level 2 has been assigned to this project.

This Project Data Sheet (PDS) does include a new start for the budget year.

This PDS is new.

2. Design, Construction, and D&D Schedule

(fiscal quarter or date)

	CD-0	CD-1	Design Complete	CD-2	CD-3A	CD-3B	CD-4
FY 2015	9/17/2013	1Q FY2015[a]	4Q FY 2016[a]	3Q FY 2016[a]	3Q FY 2016[a]	1Q FY 2017[a]	1Q FY 2021[a]

CD-0 – Approve Mission Need
CD-1 – Approve Alternative Selection and Cost Range
CD-2 – Approve Performance Baseline
CD-3A – Approve Start of Phase A Construction
CD-3B – Approve Start of Phase B Construction
CD-4 – Approve Project Completion

3. Baseline and Validation Status

(dollars in thousands)

	TEC, Design	TEC, Construction	TEC, Total	OPC[b] Except D&D	OPC, D&D	OPC, Total	TPC
FY 2015	12,090	77,910[c]	90,000[c]	1,500	0	1,500	91,500[c]

4. Project Description, Justification, and Scope

Mission Need

The mission need of this project is to increase the synergy and efficiency of biosciences and other research at Lawrence Berkeley National Laboratory (LBNL). LBNL has grown from a pioneering particle and nuclear physics laboratory into a multidisciplinary research facility with broad capabilities in physical, chemical, computational, biological, and environmental systems research in support of the Department of Energy (DOE) mission. Portions of the biosciences program at LBNL are

[a] This project is pre-CD-2, and the schedule is preliminary. Construction funds will not be executed without appropriate CD approvals.
[b] Other project costs (OPC) are funded through laboratory overhead.
[c] This project has not received CD-2 approval; funding estimates are consistent with the high end of the preliminary cost ranges. The preliminary TEC range for this project is $70,000,000 to $90,000,000. The preliminary TPC range for this project is $71,500,000 to $91,500,000.

located off-site, away from the main laboratory, and dispersed across several locations approximately twenty miles apart. This arrangement has produced research and operational capability gaps that limit scientific progress, in genomics-based biology related to energy and the environment.

Scope and Justification

Collocation of mutually supportive capabilities in close proximity to key LBNL facilities and programs will better facilitate research in genomics-based biology related to energy and the environment. The Integrative Genomics Building project will increase the synergy and efficiency of biosciences and other research at LBNL by consolidating some research operations into a single on-campus location. This project will relocate ongoing research operations currently located in commercially leased space onto the main LBNL campus and is key to realizing the potential of the genomics revolution for energy and environment research. This project will fill the present capability gaps by providing a state-of-the-art facility for biosciences research and other programs in a collaborative environment in close proximity to key LBNL facilities and programs while simultaneously increasing the operational efficiency of LBNL. Additional supporting functions such as utilities or site modifications may be included in the project, if they are deemed necessary.

This project has not yet received CD-1 approval; therefore Key Performance Parameters (KPPs) are to be determined. The table below outlines preliminary KPPs.

Key Performance Parameters (Preliminary)

Description	Threshold Value (Minimum)	Objective Value (Maximum)
Biosciences and other research space	75,000 gross square feet	95,000 gross square feet

FY 2015 funds will be used for preliminary and final design and project management and support activities.

The project will be conducted in accordance with the project management requirements in DOE O 413.3B, Program and Project Management for the Acquisition of Capital Assets, and all appropriate project management requirements will be met.

5. Financial Schedule

(dollars in thousands)

	Appropriations	Obligations	Costs
Total Estimated Cost (TEC)			
Design			
FY 2015	12,090	12,090	9,000
FY 2016	0	0	3,090
Total, Design	12,090	12,090	12,090
Construction			
FY 2016	17,299	17,299	9,910
FY 2017	30,148	30,148	30,000
FY 2018	30,463	30,463	29,000
FY 2019	0	0	7,000
FY 2020	0	0	2,000
Total, Construction	77,910	77,910	77,910

(dollars in thousands)

	Appropriations	Obligations	Costs
TEC			
FY 2015	12,090	12,090	9,000
FY 2016	17,299	17,299	13,000
FY 2017	30,148	30,148	30,000
FY 2018	30,463	30,463	29,000
FY 2019	0	0	7,000
FY 2020	0	0	2,000
Total, TEC[a]	90,000	90,000	90,000
Other Project Cost (OPC)[b]			
OPC except D&D			
FY 2014	1,300	1,300	1,300
FY 2015–2018	0	0	0
FY 2019	200	200	200
Total, OPC	1,500	1,500	1,500
Total Project Cost (TPC)			
FY 2014	1,300	1,300	1,300
FY 2015	12,090	12,090	9,000
FY 2016	17,299	17,299	13,000
FY 2017	30,148	30,148	30,000
FY 2018	30,463	30,463	29,000
FY 2019	200	200	7,200
FY 2020	0	0	2,000
Total, TPC[c]	91,500	91,500	91,500

[a] This project has not received approval of CD-2; funding estimates are consistent with the high end of the preliminary cost ranges. The preliminary TEC range is $70,000,000 to $90,000,000. The preliminary TPC range is $71,500,000 to $91,500,000.
[b] Other Project Costs (OPC) are funded through laboratory overhead.
[c] This project has not received approval of CD-2; funding estimates are consistent with the high end of the preliminary cost ranges. The preliminary TEC range is $70,000,000 to $90,000,000. The preliminary TPC range is $71,500,000 to $91,500,000.

6. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design			
Design	10,590	N/A	N/A
Contingency	1,500	N/A	N/A
Total, Design	12,090	N/A	N/A
Construction			
Construction	61,410	N/A	N/A
Contingency	16,500	N/A	N/A
Total, Construction	77,910	N/A	N/A
Total, TEC[a]	90,000	N/A	N/A
Contingency, TEC	18,000	N/A	N/A
Other Project Cost (OPC)[a]			
OPC except D&D			
Conceptual Planning	400	N/A	N/A
Conceptual Design	500	N/A	N/A
Start-Up	200	N/A	N/A
Contingency	400	N/A	N/A
Total, OPC	1,500	N/A	N/A
Contingency, OPC	400	N/A	N/A
Total, TPC[b]	91,500	N/A	N/A
Total, Contingency	18,400	N/A	N/A

[a] Other Project Costs (OPC) are funded through laboratory overhead.
[b] This project has not received approval of CD-2; funding estimates are consistent with the high end of the preliminary cost ranges. The preliminary TEC range is $70,000,000 to $90,000,000. The preliminary TPC range is $71,500,000 to $91,500,000.

7. Funding Profile History

Request Year		FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	Total
		(dollars in thousands)						
FY 2015	TEC	0	12,090	17,299	30,148	30,463	0	90,000[a]
	OPC[a]	1,300	0	0	0	0	200	1,500
	TPC	1,300	12,090	17,299	30,148	30,463	200	91,500[a]

8. Related Operations and Maintenance Funding Requirements

Not Applicable

9. Required D&D Information

Not Applicable

10. Acquisition Approach

Acquisition for this project will be performed by the LBNL Management and Operating (M&O) contractor, University of California. The M&O contractor is responsible for awarding and managing all subcontracts related to this project. The M&O contractor will evaluate various acquisition alternatives and project delivery methods prior to achieving CD-1. Potential acquisition and project delivery methods include, but are not limited to, firm fixed price contracts for design-bid-build and design-build. The M&O contractor will also evaluate potential benefits of using a single or multiple contracts to procure materials, equipment, construction, commissioning and other project scope elements. Project performance metrics for LBNL will be included in the M&O contractor's annual performance and evaluation measurement plan.

[a] Other Project Costs (OPC) are funded through laboratory overhead.

12-SC-70, Science and User Support Building
SLAC National Accelerator Laboratory (SLAC), Menlo Park, California
Project is for Design and Construction

1. Significant Changes

The most recent DOE O 413.3B approved Critical Decision (CD) is CD-2/3, *Approve Performance Baseline; Approve Start of Construction*, which was approved June 18, 2013. The Total Estimated Cost (TEC) for this project is $64,000,000. The Total Project Cost (TPC) this project is $65,000,000.

A Federal Project Director with a certification level 3 has been assigned to this project.

This Project Data Sheet (PDS) does not include a new start for the budget year.

This PDS is an update of the FY 2014 PDS. Since that submittal, the design cost has been revised downward from $5,000,000 to $1,815,000. The construction estimate has been revised upward by an equal amount such that there is no net increase to TEC.

2. Design, Construction, and D&D Schedule

(fiscal quarter or date)

	CD-0	CD-1	Design Complete	CD-2/3	CD-4	D&D Start	D&D Complete
FY 2012	8/26/2010	2Q FY 2012	4Q FY 2013	TBD	TBD	TBD	TBD
FY 2013	8/26/2010	3Q FY 2012	2Q FY 2013	2Q FY 2013	4Q FY 2016	3Q FY 2012	4Q FY 2016
FY 2014	8/26/2010	5/11/2012	2Q FY 2014	3Q FY 2013	3Q FY 2017	3Q FY 2012	4Q FY 2016
FY 2015	8/26/2010	5/11/2012	2Q FY 2014	6/18/2013	3Q FY 2017	8/30/2013	4Q FY 2016

CD-0 – Approve Mission Need
CD-1 – Approve Alternative Selection and Cost Range
CD-2/3 – Approve Performance Baseline; Approve Start of Construction
CD-4 – Approve Start of Operations or Project Closeout
D&D Start – Start of Demolition & Decontamination (D&D) work
D&D Complete – Completion of D&D work

3. Baseline and Validation Status

(dollars in thousands)

	TEC, Design	TEC Construction	TEC, Total	OPC[a] Except D&D	OPC, D&D	OPC, Total	TPC
FY 2012	5,000	59,000	64,000	1,000	TBD	1,000	65,000
FY 2013	5,000	59,000	64,000	1,000	0	1,000	65,000
FY 2014	5,000	59,000	64,000	1,000	0	1,000	65,000
FY 2015	1,815	62,185	64,000	1,000	0	1,000	65,000

[a] Other Project Costs are funded through laboratory overhead.

4. Project Description, Justification, and Scope

Mission Need

SLAC is an Office of Science laboratory that supports a large national and international community of scientific users performing cutting edge research in support of the Department of Energy mission. SLAC is home to research activities in materials and chemical sciences that build on ultrafast and advanced synchrotron techniques. SLAC also operates beamlines for structural biology and supports efforts in particle physics and particle astrophysics. SLAC operates and is strongly positioned by the Linac Coherent Light Source (LCLS) and the Stanford Synchrotron Radiation Light Source (SSRL).

The demand to use SLAC's unique research facilities is rapidly increasing. This has resulted in a critical gap in SLAC's mission capability due to inadequate centralized support for its user community and lack of modern, collaborative infrastructure to support a world-class research program.

The SLAC Science and User Support building will close the mission capability gap and ensure that the world-class research conducted by SLAC scientific staff and users is supported by modern, mission-ready facilities. Located at the entrance to the Laboratory, this building will be the first stop for all users and visitors to SLAC, and will bring together many of the Laboratory's user, visitor, and administrative services. This will enhance scientific productivity and collaboration that better supports the laboratory's cutting-edge discoveries and exceptional user research program.

Scope and Justification (12-SC-70, Science and User Support Building at SLAC)

This project will construct a 62,400 square foot building that will house a centrally located user support hub; the visitor's center; a new cafeteria; office space needed to centralize SLAC communications, security, and laboratory administration; and a state-of-the-art auditorium and conference space. The Science and User Support Building will replace the aging structure that currently holds Panofsky Auditorium and the cafeteria built in 1962, the same year SLAC was founded. In order to meet the congressional mandates for replacement, the project plans to demolish the Panofsky Auditorium building (approximately 13,200 gsf) and use banked excess for the balance.

Key Performance Parameters

Description	Threshold Value (Minimum)	Objective Value (Maximum)
Multistory Office Building	58,000 gross square feet	72,000 gross square feet

FY 2015 construction funding will support construction activities on this project, including project management and all associated support functions. FY 2015 is the final year of funding for this project and includes $9.8M for contingency.

The project is being conducted in accordance with the project management requirements in DOE Order 413.3B, Program and Project Management for the Acquisition of Capital Assets, and all appropriate project management requirements have been met.

5. Financial Schedule

(dollars in thousands)

	Appropriations	Obligations	Costs
Total Estimated Cost (TEC)			
Design			
FY 2012	1,815	1,815	1,150
FY 2013	0	0	590
FY 2014	0	0	75
Total, Design	1,815	1,815	1,815

(dollars in thousands)

	Appropriations	Obligations	Costs
Construction			
FY 2012	10,271	10,271	0
FY 2013	14,512	14,512	4,242
FY 2014	25,482	25,482	25,000
FY 2015	11,920	11,920	32,643
FY 2016	0	0	300
Total, Construction	62,185	62,185	62,185
TEC			
FY 2012	12,086	12,086	1,150
FY 2013	14,512	14,512	4,832
FY 2014	25,482	25,482	25,075
FY 2015	11,920	11,920	32,643
FY 2016	0	0	300
Total, TEC	64,000	64,000	64,000
Other Project Cost (OPC)[a]			
OPC except D&D			
FY 2011	562	562	562
FY 2014	238	238	238
FY 2015	200	200	200
Total, OPC except D&D	1,000	1,000	1,000
Total Project Cost (TPC)			
FY 2011	562	562	562
FY 2012	12,086	12,086	1,150
FY 2013	14,512	14,512	4,832
FY 2014	25,720	25,720	25,313
FY 2015	12,120	12,120	32,843
FY 2016	0	0	300
Total, TPC	65,000	65,000	65,000

[a] Other Project Costs are funded through laboratory overhead.

6. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design			
Design	1,815	4,150	5,000
Contingency	0	850	0
Total, Design	1,815	5,000	5,000
Construction			
Construction	51,185	46,000	48,000
D&D	1,200	1,200	1,200
Contingency	9,800	11,800	9,800
Total, Construction	62,185	59,000	59,000
Total, TEC	64,000	64,000	64,000
Contingency, TEC	9,800	12,650	9,800
OPC[a]			
Other OPC	500	500	500
Start-Up	300	300	300
Contingency	200	200	200
Total, OPC	1,000	1,000	1,000
Total, TPC	65,000	65,000	65,000
Total, Contingency	10,000	12,850	10,000

7. Funding Profile History

(dollars in thousands)

Request Year		FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	Total
FY 2012	TEC	0	12,086	TBD	TBD	TBD	TBD
	OPC	500	300	200	0	0	1,000
	TPC	500	12,386	TBD	TBD	TBD	TBD
FY 2013	TEC	0	12,086	21,629	30,285	0	64,000
	OPC	500	0	0	300	200	1,000
	TPC	500	12,086	21,629	30,585	200	65,000

[a] Other Project Costs are funded through laboratory overhead.

Request Year		FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	Total
		(dollars in thousands)					
FY 2014	TEC	0	12,086	12,160[a]	25,482	4,803	64,000
	OPC	500	0	0	300	200	1,000
	TPC	500	12,086	12,160	25,782	5,003	65,000
FY 2015	TEC	0	12,086	14,512	25,482	11,920	64,000
	OPC	562	0	0	238	200	1,000
	TPC	562	12,086	14,512	25,720	12,120	65,000

8. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy	3Q FY2017
Expected Useful Life	50
Expected Future Start of D&D of this capital asset	3Q FY2067

(Related Funding requirements)

(dollars in thousands)

	Annual Costs		Life Cycle Costs	
	Current Total Estimate	Previous Total Estimate	Current Total Estimate	Previous Total Estimate
Operations	135	N/A	6,750	N/A
Maintenance	405	N/A	20,400	N/A
Total, Operations & Maintenance	540	N/A	27,150	N/A

9. Required D&D Information

	Square Feet
Area of new construction	62,400
Area of existing facility(ies) being replaced and D&D'd by this project	13,200
Area of other D&D outside the project	0
Area of any additional D&D space to meet the "one-for-one" requirement taken from the banked area.	49,200

The Science and User Support Building will replace the aging 13,200 gross square foot structure that currently holds the Panofsky Auditorium and the cafeteria, built in 1962, the same year SLAC was founded. In order to meet the congressional mandates for one-for-one replacement, the project plans to demolish the Panofsky Auditorium building and cafeteria; and use SC's banked excess space at SLAC for the balance.

[a] The FY 2013 amount shown reflects the P.L. 112-175 continuing resolution level annualized to a full year. The TEC, OPC, and TPC totals and outyear appropriation assumptions have not been adjusted to reflect the final FY 2013 funding level; the FY 2013 Request level of $21,629,000 is assumed instead.

10. Acquisition Approach

SLAC as the Management and Operating (M&O) contractor will have the primary responsibility for oversight of design and construction subcontracts, LEED, commissioning, and estimating services necessary to execute this project scope. Design will be performed by an architect-engineer (A-E) with the subcontract managed by the SLAC operating contractor. Final design and construction will occur concurrently using the design-build project delivery method. SLAC Site Office provides contract oversight for SLAC's plans and performance. Project performance metrics for SLAC are included in the M&O contractor's annual performance evaluation and measurement plan.

Safeguards and Security

Overview

The Safeguards and Security (S&S) program mission is to support Departmental research at Office of Science (SC) laboratories by ensuring appropriate levels of protection against unauthorized access, theft, or destruction of Department assets. The S&S program mission also includes protection against hostile acts that may cause adverse impacts on fundamental science, national security, the health and safety of DOE and contractor employees, the public, or the environment. In order to execute this mission, the S&S program focuses on securing and protecting Special Nuclear Materials, protecting classified and unclassified controlled information, providing physical security controls at and around SC national laboratories, and ensuring that the laboratories have rigorous cyber security controls to protect sensitive and classified government data.

Based on complex-wide oversight security reviews, the S&S program is implementing sound, improved security practices at our laboratories to accomplish the mission. However, there are a few critical challenges our laboratories face that will require increased investment. The program's first priority is to provide security for the Special Nuclear Materials at the Oak Ridge National Laboratory (ORNL). Next, we must address the increasing cyber security threat, balancing investments in that area with the need to continue providing adequate resources for the ongoing physical security posture at our laboratories. Finally, where possible, we invest in physical security systems such as video surveillance and secure, automated entry to simultaneously make more efficient use of funds and improve laboratory security.

Highlights of the FY 2015 Budget Request

Ensuring nuclear security is among our most important commitments to the American taxpayer. In keeping with that focus, a critical challenge the SC S&S program faces is assuring adequate security for the special nuclear material housed in Building 3019 at the Oak Ridge National Laboratory. The 2012 security breach at the Y-12 complex prompted a thorough review of our posture, both current and planned, at that facility. These reviews highlighted opportunities for improvement that are being pursued vigorously. In addition, a new Protective Force contractor was brought on board in March 2013. As we continue to assess and improve security for Building 3019, we are increasing the level of investment needed to protect this facility. This increase will pay for improvements to security technologies, as well as the increasing costs of training, and special response capabilities.

The S&S program is working to consolidate the Central Alarm Station (CAS) activities being performed separately at the Oak Ridge Office (ORO), Oak Ridge National Laboratory (ORNL), and East Tennessee Technology Park (ETTP) into one central CAS operation. Once completed, this consolidation will provide SC with a full integration of alarm monitoring, system engineering, testing, maintenance, access controls, and overall accountability for CAS operations. This plan is expected to provide SC with added efficiencies by reducing the number of full time employee positions required to support these operations and by eliminating the continued cost to support alarm components reaching their end of life cycles at two additional facilities. Funding for this project began in FY 2013 and will continue in FY 2014 and FY 2015.

The Department is also collectively implementing a strategy for managing enterprise-wide identify management and cyber-security for DOE systems and data, referred to as "CyberOne," which is managed through the Working Capital Fund. The CyberOne strategy will implement DOE Enterprise capabilities for incident management and HSPD-12 logical access. SC's portion of this investment is reflected in the increase for Cyber Security in the FY 2015 request.

Description

The S&S program is organized into seven functional areas: Protective Forces, Security Systems, Information Security, Cyber Security, Personnel Security, Material Control and Accountability, and Program Management.

Protective Forces

The Protective Forces element supports security officers, access control officers, and security policy officers assigned to protect S&S interests. Activities within this element include access control and security response operations as well as physical protection of the Department's critical assets and SC facilities. The Protective Forces mission includes providing effective response to emergency situations, random prohibited article inspections, security alarm monitoring, and performance testing of the protective force response to various event scenarios.

Security Systems

The Security Systems element provides physical protection of Departmental material, equipment, property, and facilities, and includes buildings, fences, barriers, lighting, sensors, surveillance devices, entry control devices, access control systems, and power systems operated and used to support the protection of DOE property, classified information, and other interests of national security.

Information Security

The Information Security element provides support to ensure that sensitive and classified information is accurately and consistently identified, reviewed, marked, protected, transmitted, stored, and ultimately destroyed. Specific activities within this element include management, planning, training, and oversight for maintaining security containers and combinations, marking documents, and administration of control systems, operations security, special access programs, technical surveillance countermeasures, and classification and declassification determinations.

Cyber Security

The Cyber Security element provides staffing for appropriate risk management tools and controls for sensitive or classified information that is electronically processed, transmitted, or stored. Risk management controls ensure that information systems, including the information contained within the systems, maintain confidentiality, integrity, and availability in a manner consistent with the SC mission.

Personnel Security

The Personnel Security element encompasses the processes for employee suitability and security clearance determinations at each site to ensure that individuals are trustworthy and eligible for access to classified information or matter. This element also includes the management of security clearance programs, adjudications, security education and awareness programs for Federal and contractor employees, and processing and hosting approved foreign visitors.

Material Control and Accountability (MC&A)

The MC&A element provides assurance that Departmental materials are properly controlled and accounted for at all times. This element supports administration, including testing performance and assessing the levels of protection, control, and accountability required for the types and quantities of materials at each facility; documenting facility plans for materials control and accountability; assigning authorities and responsibilities for MC&A functions; and establishing programs to detect and report occurrences such as material theft, the loss of control or inability to account for materials, or evidence of malevolent acts.

Program Management

The Program Management element coordinates the management of Protective Forces, Security Systems, Information Security, Personnel Security, Cyber Security, and MC&A to achieve and ensure appropriate levels of protections are in place.

Safeguards and Security Funding ($K)

	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Protective Forces	34,693	38,141	38,141	38,388	+247
Security Systems	10,165	13,319	13,319	13,521	+202
Information Security	4,119	4,164	4,164	4,432	+268
Cyber Security	15,646	17,599	17,599	23,908	+6,309
Personnel Security	4,760	5,143	5,143	5,180	+37
Material Control and Accountability	2,283	2,397	2,397	2,061	-336
Program Management	5,840	6,237	6,237	6,510	+273
Total, Safeguards and Security	**77,506**	**87,000**	**87,000**	**94,000**	**+7,000**

Safeguards and Security

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Protective Forces		
FY 2014 funding supports SC's portion of the Protective Forces Contract at Oak Ridge and maintains protection levels, equipment, facilities, and training needed to ensure effective performance at all SC laboratories.	The FY 2015 Request provides funding to maintain protection levels, equipment, facilities, and training needed to ensure proper protection and effective performance at all SC laboratories.	The increased request addresses cost of living adjustments and provides funding to maintain appropriate Protective Force operations at Building 3019 at Oak Ridge to include costs of shared training, technical surveillance services, and response capabilities.
Security Systems		
FY 2014 funding supports the CAS consolidation project at ORNL and the federal access control systems and upgrades needed to meet HSPD-12 requirements and implementation of technologies that will incrementally reduce reliance on the use of personnel for routine access control, employee verification, and other security services.	The FY 2015 Request provides funding to maintain the security systems currently in place, to support investments in SC laboratory physical security systems, and provides funding to support the continuation of the CAS consolidation project at ORNL.	Funding increases to support the continuation of the CAS consolidation project and to support implementation of technology upgrades and infrastructure investments in SC laboratory physical security systems, including those at Building 3019 that will improve security at laboratories and reduce reliance on the use of personnel for routine access control and employee verification processes.
Information Security		
FY 2014 funding maintains Information Security efforts to ensure proper document marking, storage, and protection of information.	The FY 2015 Request provides funding for personnel, equipment, and systems necessary to ensure sensitive and classified information is properly safeguarded at SC laboratories.	Funding increases to address adjustments in volume of DOE classified work and to provide the support needed to ensure proper processing of these materials.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Cyber Security		
FY 2014 funding supports cyber security staffing needed to ensure laboratories are properly protected against emerging threats from persistent attacks against SC Information Technology systems. Funding supports threat assessments, risk management, and configuration and network management.	The FY 2015 Request maintains proper protection of SC laboratory computer resources and data and also supports SC's contribution of the Department's CyberOne strategy, which is managed through the Working Capital Fund. CyberOne is the Department's solution for managing enterprise-wide identity management and cyber-security for DOE systems and data. CyberOne will consolidate and streamline Department-wide systems and business processes to mitigate the risk of intrusion and the threat such intrusions pose to high-valued national assets. CyberOne will integrate various tools at headquarters and across the DOE complex to secure both data transmission and data repositories at these diverse sites.	The increased request provides $7,351,000 to support SC's contribution to the Department's CyberOne strategy.
Personnel Security		
Funding supports the necessary laboratory personnel to grant individual access to classified matter and/or special nuclear material and to allow foreign nationals access to SC facilities, consistent with agency procedures. Funding also supports security investigations for federal field personnel and security awareness programs for employees.	FY 2015 funding will maintain support and Personnel Security efforts at SC laboratories.	Funding increases slightly to accommodate support for security investigations for Federal field personnel.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Material Control and Accountability		
Funding provides for establishing, controlling, and tracking inventories of special and other nuclear materials at SC laboratories. Activities supported by these funds include measurements, quality assurance, accounting, containment, surveillance, and physical inventories of materials.	Funding in FY 2015 maintains proper protection of material at SC laboratories.	Funding decreases to accommodate changes in site specific MC&A programs.
Program Management		
FY 2014 funding maintains efforts to ensure security procedures and policy support the SC Research mission.	The FY 2015 Request provides funding for the oversight, administration, and planning for security programs at SC laboratories and to ensure security procedures and policy support SC Research missions.	Funding increases to accommodate laboratory and program priorities and maintain Program Management activities.

Safeguards and Security
Capital Summary ($K)

	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Capital Operating Expenses Summary					
General Plant Projects	1,100	0	0	0	0

Estimates of Cost Recovered for Safeguards and Security Activities ($K)

In addition to the direct funding received from the Safeguards and Security Program, sites recover Safeguards and Security costs related to Work for Others (WFO) activities from WFO customers, including the cost of any unique security needs directly attributable to the customer. Estimates of those costs are shown below.

	FY 2013 Costs	FY 2014 Planned Costs	FY 2015 Planned Costs	FY 2015 vs. FY 2014
Ames National Laboratory	120	120	120	0
Argonne National Laboratory	1,100	1,100	1,100	0
Brookhaven National Laboratory	700	800	800	0
Lawrence Berkeley National Laboratory	698	733	733	0
Oak Ridge Institute for Science and Education	620	560	560	0
Oak Ridge National Laboratory	4,500	4,500	4,500	0
Pacific Northwest National Laboratory	4,555	4,300	4,300	0
Princeton Plasma Physics Laboratory	70	50	40	-10
SLAC National Accelerator Laboratory	80	104	104	0
Total, Security Cost Recovered	12,443	12,267	12,257	-10

Program Direction

Overview

The Office of Science's (SC) Program Direction (PD) mission is to support and sustain a skilled and motivated Federal workforce to develop and oversee SC investments in world-leading research and scientific user facilities. SC investments deliver scientific discoveries and technological innovations to solve our Nation's energy and environmental challenges and enable the United States to maintain its global competitiveness. In addition, SC provides easy public access to DOE's scientific findings to further leverage the Federal science investment and advance the scientific enterprise.

Carrying out SC's mission requires highly skilled scientific and technical program and project managers, as well as experts in areas such as acquisition, finance, legal, construction and infrastructure management, human resources, and environmental, safety, and health oversight. SC's Federal workforce plans, executes, and manages science programs that meet critical national needs. National challenges in energy, environmental stewardship, and nuclear security, as well as continued U.S. innovation and scientific competitiveness, all rely upon transformational basic research. Oversight of DOE's basic research portfolio, which includes grants and contracts supporting about 22,000 researchers located at 300 universities and 17 national laboratories, as well as supervision of major construction projects, is a Federal responsibility. SC also enables world-leading research by providing and maintaining state-of-the-art scientific user facilities—the large machines of modern science—supporting nearly 28,000 users. These facilities offer unique capabilities and place U.S. researchers and industries at the forefront of science, technology, and innovation. With adequate staffing levels and a workforce with appropriate skills, education, and experience, SC is an effective and efficient steward that utilizes taxpayer dollars for maximum national benefit.

Headquarters (HQ)

SC HQ Federal staff provide policy, strategy, and resource management for the SC enterprise. The following activities are performed:

- Maintain a balanced research portfolio that includes high-risk, high-reward research to maximize the program's potential to achieve mission goals and objectives.
- Conduct scientific program planning, execution, and management across a broad spectrum of scientific disciplines and program offices; and communicates research interests and priorities to the scientific community.
- Assure rigorous external merit review of research proposals, selection of appropriate peer review experts, development of award recommendations informed by peer review, and regular evaluation of research programs. Each year, SC typically receives between 5,000 and 6,000 new and renewal proposals that require peer review, in addition to managing over 6,000 laboratory, university, non-profit, and private industry research awards already in progress.
- Provide oversight and management of the Science Laboratories Infrastructure program and the maintenance and operational integrity of 10 SC national laboratories.
- Provide policy, strategy, and resource management in the areas of information technology, grants and contracts, budget, and human capital.

Site Offices

SC Site Office Federal staff maintain the business and management infrastructure required to support the scientific mission at 10 SC national laboratories. This includes conducting day-to-day business transactions of contract management activities, approvals to operate hazardous facilities, safety and security oversight, leases, property transfers, sub-contracts, and activity approvals required by laws, regulations, and DOE policy. As part of this, the Site Offices:

- Maintain a comprehensive contract management program to assure contractual mechanisms, supporting over $3 billion per year of SC mission work performed by contractors at 10 SC national laboratories, are managed effectively and consistently with guidelines and regulations.
- Evaluate complex integrated laboratory activities including nuclear, radiological, and other complex hazards.
- Provide Federal project directors to facilitate execution of line item and other construction projects.

Integrated Support Center (ISC)

The ISC, located at the Chicago and Oak Ridge Offices, provides the business infrastructure to support the SC enterprise. These functions include legal and technical support; financial management; grant and contract processing; safety, security, and health management; labor relations, intellectual property and patent management; environmental compliance; facility infrastructure operations and maintenance; and information systems development and support. As part of this, the ISC:

- Manages the multi-appropriation, multi-program allotments for all SC national laboratories and is responsible for over 90% of SC funds.
- Provides support to SC and other DOE programs for solicitations and funding opportunity announcements, as well as the negotiation, award, administration, and closeout of contracts and financial assistance awards using certified contracting officers and professional acquisition staff.

Office of Scientific and Technical Information (OSTI)

OSTI fulfills the Department's responsibilities for public access to the unclassified results of its research investments, as well as the collection and secured access to DOE's classified and sensitive scientific and technical information. In addition to ensuring long-term preservation, OSTI develops and maintains publicly-accessible web products offering technical reports, conference papers, patents, accepted manuscripts, videos, and datasets produced through the research of DOE's national laboratories and grantees. DOE researchers typically produce 30,000-40,000 research papers annually, and OSTI's physical and electronic collections exceed 1 million research papers. OSTI leverages its expertise in federated search technology to achieve transparency and openness so that citizens can easily find government scientific information without knowing specific organizational structures and sources.

Highlights of the FY 2015 Budget Request

- FY 2015 is an increase of $4,393,000, or 2.4%, from the FY 2014 appropriation and supports a total FTE level of 975, backfill hiring for only essential SC positions, and targeted recruitment efforts based on contemporary skill requirements.
- In 2013, Secretary Moniz announced plans for a reorganization of the Department's management structure that is designed to achieve several key priorities. Successful implementation of the President's Climate Action Plan, energy strategy, and nuclear security agenda require the appropriate alignment of management functions and strengthened management throughout the agency. The reorganization affects the structure of the Department at the Under Secretary level. It expands the role of the Under Secretary for Science to encompass both science and energy. The resulting Office of the Under Secretary for Science and Energy will manage the Office of Science (SC), as well as the offices of Fossil Energy (FE), Energy Efficiency and Renewable Energy (EERE), Nuclear Energy (NE), Electricity Delivery and Energy Reliability (OE), and Indian Energy (IE), and the Technology Transfer Coordinator. The FY 2015 Request includes $2.26 million for the five positions created for this newly expanded Under Secretary office.
- Science was granted authority to offer Voluntary Early Retirement Authority/Voluntary Separation Incentive Pay (VERA/VSIP) in targeted areas of the organization in FY 2014. As part of ongoing efforts to improve internal controls and increase transparency, salaries and benefits for all of SC were consolidated at the start of FY 2014 and are now centrally managed at HQ. The FY 2015 funding request for salaries and benefits, shown at OSTI, the ISC and the Field Offices will continue to be managed at HQ.
- Consistent with Executive Order 13539, as amended December 19, 2011, the FY 2015 request supports the President's Council of Advisors on Science and Technology (PCAST), providing $925,000 for salaries and benefits for 2 FTEs, committee member travel, meeting planning support, and other related expenses.

Science Program Direction
Funding ($K)

	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
		Program Direction Summary			
Washington Headquarters					
Salaries and Benefits	51,025	52,460	52,460	52,989	+529
Travel	1,497	1,766	1,766	2,326	+560
Support Services	8,564	14,450	14,450	13,044	-1,406
Other Related Expenses	9,886	14,955	14,955	16,828	+1,873
Total, Washington Headquarters	**70,972**	**83,631**	**83,631**	**85,187**	**+1,556**
Office of Scientific and Technical Information					
Salaries and Benefits	5,601	6,110	6,110	6,302	+192
Travel	74	76	76	78	+2
Support Services	1,764	1,284	1,284	1,272	-12
Other Related Expenses	865	961	961	1,000	+39
Total, Office of Scientific and Technical Information	**8,304**	**8,431**	**8,431**	**8,652**	**+221**
Field Offices					
Chicago Office					
Salaries and Benefits	22,680	22,100	22,100	22,846	+746
Travel	286	248	248	305	+57
Support Services	1,813	810	810	800	-10
Other Related Expenses	1,140	2,344	2,344	1,958	-386
Total, Chicago Office	**25,919**	**25,502**	**25,502**	**25,909**	**+407**
Oak Ridge Office					
Salaries and Benefits	24,746	23,819	23,819	25,014	+1,195
Travel	343	324	324	300	-24
Support Services	3,690	2,136	2,136	1,469	-667
Other Related Expenses	3,080	3,785	3,785	3,410	-375
Total, Oak Ridge Office	**31,859**	**30,064**	**30,064**	**30,193**	**+129**

	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Ames Site Office					
Salaries and Benefits	381	437	437	441	+4
Travel	20	20	20	24	+4
Support Services	0	2	2	2	0
Total, Ames Site Office	**401**	**459**	**459**	**467**	**+8**
Argonne Site Office					
Salaries and Benefits	3,383	3,496	3,496	3,684	+188
Travel	63	66	66	107	+41
Support Services	144	52	52	158	+106
Other Related Expenses	33	6	6	39	+33
Total, Argonne Site Office	**3,623**	**3,620**	**3,620**	**3,988**	**+368**
Berkeley Site Office					
Salaries and Benefits	3,582	3,597	3,597	3,468	-129
Travel	54	59	59	75	+16
Support Services	362	223	223	384	+161
Other Related Expenses	59	75	75	131	+56
Total, Berkeley Site Office	**4,057**	**3,954**	**3,954**	**4,058**	**+104**
Brookhaven Site Office					
Salaries and Benefits	3,997	4,290	4,290	4,500	+210
Travel	83	129	129	115	-14
Support Services	347	246	246	610	+364
Other Related Expenses	512	218	218	165	-53
Total, Brookhaven Site Office	**4,939**	**4,883**	**4,883**	**5,390**	**+507**
Fermi Site Office					
Salaries and Benefits	2,258	2,258	2,258	2,280	+22
Travel	58	61	61	75	+14
Support Services	74	28	28	73	+45
Other Related Expenses	41	13	13	44	+31
Total, Fermi Site Office	**2,431**	**2,360**	**2,360**	**2,472**	**+112**

	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
New Brunswick Laboratory					
Salaries and Benefits	4,244	4,104	4,104	4,430	+326
Travel	74	80	80	80	0
Support Services	742	296	296	296	0
Other Related Expenses	800	983	983	983	0
Total, New Brunswick Laboratory	**5,860**	**5,463**	**5,463**	**5,789**	**+326**
Oak Ridge National Laboratory Site Office					
Salaries and Benefits	5,060	5,619	5,619	5,875	+256
Travel	57	95	95	110	+15
Support Services	651	240	240	281	+41
Other Related Expenses	52	15	15	30	+15
Total, Oak Ridge National Laboratory Site Office	**5,820**	**5,969**	**5,969**	**6,296**	**+327**
Pacific Northwest Site Office					
Salaries and Benefits	4,640	4,725	4,725	4,636	-89
Travel	107	131	131	125	-6
Support Services	61	41	41	38	-3
Other Related Expenses	63	14	14	104	+90
Total, Pacific Northwest Site Office	**4,871**	**4,911**	**4,911**	**4,903**	**-8**
Princeton Site Office					
Salaries and Benefits	1,458	1,450	1,450	1,505	+55
Travel	23	39	39	30	-9
Support Services	81	16	16	10	-6
Other Related Expenses	29	43	43	88	+45
Total, Princeton Site Office	**1,591**	**1,548**	**1,548**	**1,633**	**+85**
SLAC Site Office					
Salaries and Benefits	2,244	2,204	2,204	2,226	+22
Travel	23	50	50	59	+9
Support Services	133	40	40	138	+98
Other Related Expenses	57	33	33	57	+24
Total, SLAC Site Office	**2,457**	**2,327**	**2,327**	**2,480**	**+153**

	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Thomas Jefferson Site Office					
Salaries and Benefits	1,682	1,818	1,818	1,836	+18
Travel	46	48	48	50	+2
Support Services	5	6	6	49	+43
Other Related Expenses	25	6	6	41	+35
Total, Thomas Jefferson Site Office	**1,758**	**1,878**	**1,878**	**1,976**	**+98**
Total Field Offices					
Salaries and Benefits	80,355	79,917	79,917	82,741	+2,824
Travel	1,237	1,350	1,350	1,455	+105
Support Services	8,103	4,136	4,136	4,308	+172
Other Related Expenses	5,891	7,535	7,535	7,050	-485
Total, Field Offices	**95,586**	**92,938**	**92,938**	**95,554**	**+2,616**
Total Program Direction					
Salaries and Benefits	136,981	138,487	138,487	142,032	+3,545
Travel	2,808	3,192	3,192	3,859	+667
Support Services	18,431	19,870	19,870	18,624	-1,246
Other Related Expenses	16,642	23,451	23,451	24,878	+1,427
Total, Program Direction	**174,862**	**185,000**	**185,000**	**189,393**	**+4,393**
Federal FTEs	956	956	956	975	+19

Support Services and Other Related Expenses

	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Technical Support					
Development of specifications	1,492	482	482	464	-18
System review and reliability analyses	269	682	682	700	+18
Surveys or reviews of technical operations	730	384	384	365	-19
Total, Technical Support	**2,491**	**1,548**	**1,548**	**1,529**	**-19**
Management Support					
Automated data processing	7,028	7,110	7,110	7,575	+465
Training and education	781	692	692	724	+32
Reports and analyses, management, and general administrative services	8,131	10,520	10,520	8,796	-1,724
Total, Management Support	**15,940**	**18,322**	**18,322**	**17,095**	**-1,227**
Total, Support Services	**18,431**	**19,870**	**19,870**	**18,624**	**-1,246**

	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Other Related Expenses					
Rent to GSA	23	975	975	900	-75
Rent to others	1,042	1,679	1,679	1,456	-223
Communications, utilities, and miscellaneous	3,008	3,381	3,381	1,924	-1,457
Printing and reproduction	3	30	30	21	-9
Other services	1,356	1,917	1,917	2,510	+593
Operation and maintenance of equipment	214	103	103	103	0
Operation and maintenance of facilities	1,359	1,029	1,029	1,044	+15
Supplies and materials	801	586	586	776	+190
Equipment	2,621	3,751	3,751	4,036	+285
Working Capital Fund	6,215	10,000	10,000	12,108	+2,108
Total, Other Related Expenses	**16,642**	**23,451**	**23,451**	**24,878**	**+1,427**

Program Direction

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Salaries and Benefits		
The FY 2014 appropriation supports 956 FTEs and provides for scientific oversight, project management, essential operations support associated with science program portfolio management, and administration of PCAST. The FY 2014 appropriation allows for SC to begin implementation of its succession planning strategy, including VERA/VSIP at HQ and strict hiring controls across the SC organization.	The FY 2015 Request for 975 FTEs supports scientific oversight, project management, essential operations support associated with science program portfolio management, and administration of PCAST. The FY 2015 Request allows for backfill hiring for essential SC positions and allows for SC to continue implementation of its succession planning strategy.	The FY 2015 Request is an increase of 19 FTEs from FY 2014 and allows for backfill hiring for essential SC positions and continued implementation of its succession planning strategy.
Support for expenses such as increases in GS schedule pay rates, health coverage costs and retirement allocations in the Federal Employees Retirement System are included. Expenses associated with VERA/VSIP are also included.	Support for expenses such as increases in GS schedule pay rates, health coverage costs and retirement allocations in the Federal Employees Retirement System are included.	
	The FY 2015 Request includes funding for costs associated with the creation of five positions in the newly expanded Office of the Under Secretary for Science and Energy and one additional FTE to support new PCAST requirements.	The FY 2015 Request also supports costs associated with the creation of five positions in the newly expanded Office of the Under Secretary for Science and Energy and one additional FTE to support new PCAST requirements.
Travel		
Staff travel is required to ensure scientific management, compliance, safety oversight, and external review of research funding across all SC programs, since SC senior program managers are not co-located with grantees or at national laboratories. Travel is also required for facility visits where the use of electronic telecommunications is not practical for mandated on-site inspections and operations reviews.	Staff travel is required to ensure scientific management, compliance, safety oversight, and external review of research funding across all SC programs, since SC senior program managers are not co-located with grantees or at national laboratories. Travel is also required for facility visits where the use of electronic telecommunications is not practical for mandated on-site inspections and operations reviews.	Travel increases from FY 2014 due to additional responsibilities associated with the newly expanded Office of the Under Secretary for Science and Energy.
Travel is also included to support meetings of the PCAST, scheduled for six times per year with	Travel is also included to support meetings of the PCAST, scheduled for six times per year with	

FY 2014 Enacted	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
additional meetings called at the discretion of the President. PCAST is an advisory group to the President and Executive Office of the President. SC Federal Advisory Committee travel is supported, which includes 173 representatives from universities, national laboratories, and industry, representing a diverse balance of disciplines, professional experience, and geography. Each of the six advisory committees provides valuable, independent advice to the Department regarding the complex scientific and technical issues that arise in the planning, management, and implementation of SC programs.	additional meetings called at the discretion of the President. PCAST is an advisory group to the President and Executive Office of the President. SC Federal Advisory Committee travel is supported, which includes 173 representatives from universities, national laboratories, and industry, representing a diverse balance of disciplines, professional experience, and geography. Each of the six advisory committees provides valuable, independent advice to the Department regarding the complex scientific and technical issues that arise in the planning, management, and implementation of SC programs. Travel is included to support five new FTEs in the newly expanded Office of the Under Secretary for Science and Energy.	

FY 2014 Enacted	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Support Services		
Technical expertise and business services sustain the following: maintenance, operation, and cyber security management of SC mission-specific information technology systems and infrastructure as well as SC-corporate Enterprise Architecture and Capital Planning Investment Control management; administration of the Small Business Innovation Research/Small Business Technology Transfer program; grants and contract processing and close-out activities; accessibility to DOE's corporate multi-billion dollar R&D program through information systems managed and administered by OSTI; operations and maintenance of the Searchable Field Work Proposal system to provide HQ and Field organizations a tool to search and monitor field work proposals; selected routine administrative services including travel processing and Federal staff training and education to maintain appropriate certification and update skills; select reports or analyses directed toward improving the effectiveness, efficiency, and economy of services and processes; and safeguards and security oversight functions. The FY 2014 Appropriations funds essential information technology infrastructure and safety management support, as well as training for the SC workforce.	Technical expertise and business services sustain the following: maintenance, operation, and cyber security management of SC mission-specific information technology systems and infrastructure as well as SC-corporate Enterprise Architecture and Capital Planning Investment Control management; administration of the Small Business Innovation Research/Small Business Technology Transfer program; grants and contract processing and close-out activities; accessibility to DOE's corporate multi-billion dollar R&D program through information systems managed and administered by OSTI; operations and maintenance of the Searchable Field Work Proposal system to provide HQ and Field organizations a tool to search and monitor field work proposals; selected routine administrative services including travel processing and Federal staff training and education to maintain appropriate certification and update skills; select reports or analyses directed toward improving the effectiveness, efficiency, and economy of services and processes; and safeguards and security oversight functions. The FY 2015 Request funds essential information technology infrastructure and safety management support, as well as training for the SC workforce. The FY 2015 request incorporates the IT Modernization Plan, which is expected to be fully implemented by the end of FY 2014. This will result in a common operating environment across SC Headquarters and Integrated Support Center (Chicago and Oak Ridge). Funding for a single consolidated IT support service contract is included.	The decrease, primarily in IT support services, results from the implementation of the SC Information Technology Modernization Plan.

FY 2014 Enacted	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Other Related Expenses		
SC contribution to the Department's Working Capital Fund (WCF) provides for common administrative services at HQ including: rent and building operations, telecommunications, network connectivity, supplies, printing/graphics, mail, purchase card surveillance, overseas office support, health centers, and interagency transfer fees associated with E-gov initiatives. In addition to increases to support salary and benefit costs for staff administering the WCF, also included are fixed requirements in the Field Offices not funded through the WCF associated with rent, utilities, and telecommunications, building and grounds maintenance, computer/video maintenance and support, equipment leases, purchases, maintenance, and site-wide health care units. Also funded are SC-wide assessments for payroll processing and the Corporate Human Resource Information System. The FY 2014 appropriation supports mandatory increases in fixed costs, rent, and other WCF requirements. WCF costs represent 43% of the Other Related Expenses funding.	SC contribution to the Department's Working Capital Fund (WCF) provides for common administrative services at HQ including: rent and building operations, telecommunications, network connectivity, supplies, printing/graphics, mail, purchase card surveillance, overseas office support, health centers, and interagency transfer fees associated with E-gov initiatives. In addition to increases to support salary and benefit costs for staff administering the WCF, also included are fixed requirements in the Field Offices not funded through the WCF associated with rent, utilities, and telecommunications, building and grounds maintenance, computer/video maintenance and support, equipment leases, purchases, maintenance, and site-wide health care units. Also funded are SC-wide assessments for payroll processing and the Corporate Human Resource Information System. The FY 2015 Request supports mandatory increases in fixed costs, rent, and other WCF requirements. WCF costs represent 49% of the Other Related Expenses Request.	The overall increase is primarily due to costs associated with the Working Capital Fund. The remaining increase is not the result of any particular item, but reflects modest increases in areas corresponding to the increase in FTEs supported by the FY 2015 Request.

Science
Facilities Maintenance and Repair

The Department's Facilities Maintenance and Repair activities are tied to its programmatic missions, goals, and objectives. Facilities Maintenance and Repair activities funded by this budget are displayed below.

Costs for Direct-Funded Maintenance and Repair (including Deferred Maintenance Reduction) ($K)

	FY 2013 Actual Costs	FY 2013 Planned Costs	FY 2014 Planned Costs	FY 2015 Planned Costs
Brookhaven National Laboratory	6,044	5,995	5,515	5,681
Fermi National Accelerator Laboratory	21	139	142	152
Notre Dame Radiation Laboratory	154	58	80	105
Oak Ridge National Laboratory	15,731	15,506	15,816	16,132
Oak Ridge Office	1,714	3,032	2,581	2,989
Office of Scientific and Technical Information	363	364	372	713
Pacific Northwest National Laboratory	0	0	2,358	2,449
SLAC National Accelerator Laboratory	4,114	5,116	3,545	3,669
Thomas Jefferson National Accelerator Facility	91	65	67	69
Total, Direct-Funded Maintenance and Repair	28,232	30,275	30,476	31,959

General purpose infrastructure includes multiprogram research laboratories, administrative and support buildings, as well as cafeterias, power plants, fire stations, utilities, roads, and other structures. Together, the SC laboratories have over 1,400 operational buildings and real property trailers, with nearly 20 million gross square feet of space.

Generally, facilities maintenance and repair expenses are funded through an indirect overhead charge. In some cases, however, a laboratory may charge maintenance directly to a specific program. One example would be when maintenance is performed in a building used only by a single program. Such direct-funded charges are not directly budgeted.

Costs for Indirect-Funded Maintenance and Repair (including Deferred Maintenance Reduction) ($K)

	FY 2013 Actual Costs	FY 2013 Planned Costs	FY 2014 Planned Costs	FY 2015 Planned Costs
Ames Laboratory	1,333	1,299	1,696	1,729
Argonne National Laboratory	57,121	50,100	43,400	49,100
Brookhaven National Laboratory	35,094	35,743	37,722	38,565
Fermi National Accelerator Laboratory	15,803	16,761	17,158	18,348
Lawrence Berkeley National Laboratory	17,780	16,800	17,000	17,200
Lawrence Livermore National Laboratory	2,773	2,773	2,828	2,885
Los Alamos National Laboratory	119	119	121	123
Oak Ridge Institute for Science and Education	607	420	433	443

	FY 2013 Actual Costs	FY 2013 Planned Costs	FY 2014 Planned Costs	FY 2015 Planned Costs
Oak Ridge National Laboratory	61,036	58,458	59,627	60,820
Oak Ridge National Laboratory facilities at Y-12	1,136	761	761	761
Pacific Northwest National Laboratory	4,606	3,792	1,809	2,280
Princeton Plasma Physics Laboratory	6,469	6,460	6,730	6,875
Sandia National Laboratories	2,598	2,598	2,649	2,701
SLAC National Accelerator Laboratory	8,699	10,898	8,208	8,208
Thomas Jefferson National Accelerator Facility	6,084	5,400	5,500	5,600
Total, Indirect-Funded Maintenance and Repair	**221,258**	**212,382**	**205,642**	**215,638**

Facilities maintenance and repair activities funded indirectly through overhead charges at SC laboratories are displayed. Since this funding is allocated to all work done at each laboratory, the cost of these activities is allocated to SC and other DOE organizations, as well as other Federal agencies and other entities doing work at SC laboratories. Maintenance reported to SC for non-SC laboratories is also shown. The figures are total projected expenditures across all SC laboratories.

Institutional General Plant Projects ($K)

	FY 2013 Current	FY 2014 Enacted	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Argonne National Laboratory	12,044	13,090	15,395	+2,305
Brookhaven National Laboratory	9,453	7,740	7,740	0
Lawrence Berkeley National Laboratory	6,451	6,000	6,000	0
Oak Ridge National Laboratory	16,553	14,300	14,295	-5
Pacific Northwest National Laboratory	4,563	16,149	15,200	-949
SLAC National Accelerator Laboratory	4,390	4,344	3,714	-630
Total, IGPP	**53,454**	**61,623**	**62,344**	**+721**

Institutional General Plant Projects are construction projects that are less than $10 million and cannot be allocated to a specific program. IGPPs fulfill multi-programmatic and/or inter-disciplinary needs and are funded through site overhead. The table displays total IGPP funding across all SC laboratories by site.

This report responds to legislative language set forth in Conference Report (H.R. Conf. Rep. No. 108-10) accompanying the Consolidated Appropriations Resolution, 2003 (Public Law 108-7) (pages 886-887), which requests the Department of Energy provide an annual year-end report on maintenance expenditures to the Committees on Appropriations. This report compares the actual maintenance expenditures in FY 2013 to the amount planned for FY 2013, including Congressionally directed changes.

Science

Total Costs for Maintenance and Repair ($K)

	FY 2013 Actual Costs	FY 2013 Planned Costs
Ames Laboratory	1,333	1,299
Argonne National Laboratory	57,121	50,100
Brookhaven National Laboratory	41,138	41,738
Fermi National Accelerator Laboratory	15,824	16,900
Lawrence Berkeley National Laboratory	17,780	16,800
Lawrence Livermore National Laboratory	2,773	2,773
Los Alamos National Laboratory	119	119
Notre Dame Radiation Laboratory	154	58
Oak Ridge Institute for Science and Education	607	420
Oak Ridge National Laboratory	76,767	73,964
Oak Ridge National Laboratory facilities at Y-12	1,136	761
Oak Ridge Office	1,714	3,032
Office of Scientific and Technical Information	363	364
Pacific Northwest National Laboratory	4,606	3,792
Princeton Plasma Physics Laboratory	6,469	6,460
Sandia National Laboratories	2,598	2,598
SLAC National Accelerator Laboratory	12,813	16,014
Thomas Jefferson National Accelerator Facility	6,175	5,465
Total, Indirect-Funded Maintenance and Repair	249,490	242,657

Science
Research and Development ($K)

	FY 2013 Current	FY 2014 Enacted	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Basic	3,785,377	4,024,856	4,093,469	+68,613
Applied	60,120[a]	0	0	0
Subtotal, R&D	3,845,497	4,024,856	4,093,469	+68,613
Equipment	278,765	153,947	154,166	+219
Construction	167,151	476,368	466,150	-10,218
Total, R&D	**4,291,413**	**4,655,171**	**4,713,785**	**+58,614**

[a] Applied funding in FY 2013 represents SBIR/STTR funding transferred from other DOE programs. No applied funding is shown in FY 2014 or FY 2015 because the transfer from other DOE programs has not yet occurred.

Science
Small Business Innovative Research/Small Business Technology Transfer (SBIR/STTR) ($K)

	FY 2013 Reprogrammed/ Transferred	FY 2014 Projected	FY 2015 Request	FY 2015 vs. FY 2014 Projected
Office of Science				
Advanced Scientific Computing Research				
SBIR	11,312	13,272	15,457	+2,185
STTR	1,466	1,895	2,132	+237
Basic Energy Sciences				
SBIR	39,756	43,034	46,309	+3,275
STTR	5,154	6,148	6,387	+239
Biological and Environmental Research				
SBIR	15,613	16,890	18,077	+1,187
STTR	2,024	2,413	2,493	+80
Fusion Energy Sciences				
SBIR	6,516	7,697	7,461	-236
STTR	845	1,100	1,029	-71
High Energy Physics				
SBIR	18,405	18,916	18,098	-818
STTR	2,386	2,703	2,497	-206
Nuclear Physics				
SBIR	11,164	12,557	13,024	+467
STTR	1,447	1,794	1,796	+2
Total, Office of Science SBIR/STTR	**116,088**	**128,419**	**134,760**	**+6,341**

	FY 2013 Reprogrammed/ Transferred	FY 2014 Projected	FY 2015 Request	FY 2015 vs. FY 2014 Projected
Other DOE				
Nuclear Energy				
SBIR	9,541	0	0	0
STTR	1,237	0	0	0
Electricity Delivery & Energy Reliability				
SBIR	2,530	0	0	0
STTR	328	0	0	0
Energy Efficiency & Renewable Energy				
SBIR	24,044	0	0	0
STTR	3,625	0	0	0
Environmental Management				
SBIR	273	0	0	0
STTR	35	0	0	0
Defense Nuclear Nonproliferation				
SBIR	7,990	0	0	0
STTR	1,036	0	0	0
Fossil Energy				
SBIR	8,393	0	0	0
STTR	1,088	0	0	0
Total, Other DOE SBIR/STTR	**60,120**	**0**	**0**	**0**
Total, DOE SBIR/STTR	**176,208**	**128,419**	**134,760**	**+6,341**

Science
Safeguards and Security Crosscut ($K)

	FY 2013 Current	FY 2014 Enacted	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Protective Forces	34,693	38,141	38,388	+247
Physical Security Systems	10,165	13,319	13,521	+202
Information Security	4,119	4,164	4,432	+268
Cyber Security	15,646	17,599	23,908	+6,309
Personnel Security	4,760	5,143	5,180	+37
Material Control and Accountability	2,283	2,397	2,061	-336
Program Management	5,840	6,237	6,510	+273
Total, Safeguards and Security Crosscut	**77,506**	**87,000**	**94,000**	**+7,000**

Isotope Production and Distribution Program Fund

Overview

The Department of Energy's Isotope Program produces and sells radioactive and stable isotopes, byproducts, surplus materials, and related isotope services world-wide and operates under a revolving fund established by the 1990 Energy and Water Development Appropriations Act (Public Law 101–101), as amended by the 1995 Energy and Water Development Appropriations Act (Public Law 103–316). The combination of an annual direct appropriation and collections from isotope sales are deposited in the Isotope Production and Distribution Program Fund; both are needed to maintain the Isotope Program's viability. This revolving fund allows continuous and smooth operations of isotope production, sales, and distribution independent of the federal budget cycle and fluctuating sales revenue. An independent cost review of the fund's revenues and expenses is conducted annually.

The annual appropriation is requested as Isotope Development and Production for Research and Applications in the Office of Science Nuclear Physics program. Appropriated funds are used to maintain mission-readiness of facilities by supporting the core scientists and engineers needed to carry out the Isotope Program and the maintenance of isotope facilities to assure reliable production. In addition, the appropriation provides support for R&D activities associated with the development of new production and processing techniques for isotopes, operations support for the production of research isotopes, and support for the training of new personnel in isotope production. Each site's production expenses for processing and distributing isotopes are offset by revenue generated from sales. About 80 percent of the resources in the revolving fund are used for operations, maintenance, isotope production, and R&D for new isotope production techniques, with roughly 20 percent available for process improvements, unanticipated changes in volume, and purchases of small capital equipment, such as assay equipment and shipping containers needed to ensure on-time deliveries.

The Department has supplied isotopes and related services since the Atomic Energy Act of 1954 specified the role of the U.S. Government in isotope distribution. Substantial national and international scientific, medical, and research infrastructure relies upon the use of isotopes and is strongly dependent on the Department's products and services. Isotopes are now used for hundreds of applications that benefit society every day such as diagnostic medical imaging, cancer therapy, smoke detectors, neutron detectors for homeland security applications, explosives detection, oil exploration, and tracers for climate-related research. For example, radioisotopes are used in the diagnosis or treatment of about one-third of all patients admitted to hospitals.[a] Each year, nearly 18 million nuclear medicine imaging and therapeutic procedures are performed on patients at the approximately 5,000 nuclear medicine centers in the United States.[b] Such nuclear procedures are among the safest and most effective diagnostic tests available and enhance patient care by avoiding exploratory surgery and other invasive procedures. The Isotope Program continuously assesses isotope needs to inform program direction; for example, in FY 2013, the Isotope Program organized the second Federal workshop to assess stakeholder requirements in order to optimize the utilization of resources and assure the greatest availability of isotopes.

Isotopes are primarily produced and processed at three facilities stewarded by the Isotope Program: the Brookhaven Linac Isotope Producer (BLIP) and associated processing labs at Brookhaven National Laboratory (BNL), the Isotope Production Facility (IPF) and associated processing labs at Los Alamos National Laboratory (LANL), and processing facilities at Oak Ridge National Laboratory (ORNL). IPF and BLIP provide accelerator production capabilities, while the High Flux Isotope Reactor (HFIR) at ORNL provides reactor production capability. HFIR has the highest neutron flux available for isotope production in the United States. In addition, production and distribution activities are supported at the Advanced Test Reactor at the Idaho National Laboratory and at the Pacific Northwest National Laboratory. The Isotope Program is broadening capability by including university-supported accelerator and reactor facilities used for research, education, and isotope production that can provide cost-effective and unique production capabilities, including at the University of Washington, Washington University, the University of California at Davis, and the Missouri University Research Reactor. Most of these facilities reside in university medical departments.

[a] http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/med-use-radactiv-mat-fs.html
[b] http://interactive.snm.org/docs/whatisnucmed2.pdf

A total of $53.5 million was available in the revolving fund in FY 2013. This consisted of $18.5 million from FY 2013 appropriations and collections of $35.0 million to recover the costs of isotope production and isotope services. Collections in FY 2013 included sales of californium-252, helium-3, selenium-75, and strontium-82. Californium-252 has a variety of industrial and medical applications; helium-3 is used in neutron detectors for national security; selenium-75 is used as a radiography source; and strontium-82 has gained world-wide acceptance for use in heart imaging. In FY 2013, the Isotope Program served over 150 customers including major pharmaceutical companies, industrial users, and approximately 100 researchers at hospitals, national laboratories, other Federal agencies, universities, and private companies, with the sale of over 170 different radioactive and stable isotopes. Among the isotopes produced, seven are high-volume moderately priced isotopes; the remaining are low-volume research isotopes, which are more expensive to produce. Commercial isotopes are priced to recover full cost or the market price, whichever is higher.

Highlights of the FY 2015 Budget Request

For FY 2015, the Department foresees more than moderate growth in isotope demand. Revolving fund resources are being used to support efforts to increase radioisotope production capabilities and availability, including the re-establishment of a Federal stable isotope enrichment capability as recommended by the Nuclear Science Advisory Committee. The U.S. government has not had an isotope enrichment capability since 1998. Since that time, inventories of some enriched stable isotopes have been depleted, forcing researchers to rely upon uncertain international supplies. A U.S. enrichment capability is needed to assure the supply of enriched stable isotopes to researchers as well as assuring a domestic supply of enriched stable isotopes needed for national security applications.

Department of Energy
FY 2015 Congressional Budget
Funding By Appropriation By Site
($K)

Science	**FY 2013 Current**	**FY 2014 Appropriation**	**FY 2015 Request**
Ames Laboratory			
Advanced Scientific Computing Research	80	80	80
Basic Energy Sciences	27,920	18,781	18,281
Biological and Environmental Research	399	338	0
Fusion Energy Sciences	192	0	0
Workforce Development for Teachers and Scientists	568	0	0
Safeguards and Security	943	993	993
Total, Ames Laboratory	**30,102**	**20,192**	**19,354**
Ames Site Office			
Program Direction	401	459	467
Argonne National Laboratory			
Advanced Scientific Computing Research	83,557	63,693	97,534
Basic Energy Sciences	237,451	218,953	224,794
Biological and Environmental Research	27,729	27,937	28,503
Fusion Energy Sciences	50	90	0
High Energy Physics	19,075	15,952	15,162
Nuclear Physics	28,664	27,860	27,611
Workforce Development for Teachers and Scientists	510	0	0
Science Laboratories Infrastructure	32,030	0	7,000
Safeguards and Security	8,408	8,858	8,858
Total, Argonne National Laboratory	**437,474**	**363,343**	**409,462**
Argonne Site Office			
Program Direction	3,623	3,620	3,988
Berkeley Site Office			
Program Direction	4,057	3,954	4,058
Brookhaven National Laboratory			
Advanced Scientific Computing Research	709	250	0
Basic Energy Sciences	199,439	224,074	202,217
Biological and Environmental Research	16,307	16,234	13,383
High Energy Physics	52,551	51,185	52,375
Nuclear Physics	179,602	181,043	183,220
Workforce Development for Teachers and Scientists	2,180	0	0
Science Laboratories Infrastructure	14,530	0	0
Safeguards and Security	11,352	11,866	11,959
Total, Brookhaven National Laboratory	**476,670**	**484,652**	**463,154**
Brookhaven Site Office			
Program Direction	4,939	4,883	5,390

Department of Energy
FY 2015 Congressional Budget
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Science	**FY 2013 Current**	**FY 2014 Appropriation**	**FY 2015 Request**
Chicago Office			
Advanced Scientific Computing Research	42,478	48,183	16,517
Basic Energy Sciences	271,668	291,074	302,551
Biological and Environmental Research	131,270	107,612	69,528
Fusion Energy Sciences	137,613	129,709	116,759
High Energy Physics	125,941	116,178	111,972
Nuclear Physics	90,217	129,944	160,279
Science Laboratories Infrastructure	1,385	1,385	1,412
Safeguards and Security	77	42	44
Program Direction	25,919	25,502	25,909
Small Business Innovative Research	154,086	0	0
Small Business Technology Transfer Pilot Program	20,671	0	0
Total, Chicago Office	**1,001,325**	**849,629**	**804,971**
Fermi National Accelerator Laboratory			
Advanced Scientific Computing Research	610	458	0
Basic Energy Sciences	45	45	45
High Energy Physics	369,575	384,189	341,296
Nuclear Physics	516	281	25
Workforce Development for Teachers and Scientists	240	0	0
Science Laboratories Infrastructure	0	34,900	0
Safeguards and Security	3,259	3,433	3,433
Total, Fermi National Accelerator Laboratory	**374,245**	**423,306**	**344,799**
Fermi Site Office			
Program Direction	2,431	2,360	2,472
Golden Field Office			
Workforce Development for Teachers and Scientists	465	0	0
Idaho National Laboratory			
Basic Energy Sciences	1,700	0	0
Fusion Energy Sciences	2,440	2,710	2,610
Workforce Development for Teachers and Scientists	280	0	0
Total, Idaho National Laboratory	**4,420**	**2,710**	**2,610**
Lawrence Berkeley National Laboratory			
Advanced Scientific Computing Research	123,701	101,502	115,601
Basic Energy Sciences	163,021	148,218	150,782
Biological and Environmental Research	135,436	138,405	136,181
Fusion Energy Sciences	5	0	0
High Energy Physics	64,766	62,877	58,575
Nuclear Physics	19,103	16,692	16,784
Workforce Development for Teachers and Scientists	1,507	0	0
Science Laboratories Infrastructure	0	0	12,090
Safeguards and Security	4,867	5,624	5,127
Total, Lawrence Berkeley National Laboratory	**512,406**	**473,318**	**495,140**

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Science	FY 2013 Current	FY 2014 Appropriation	FY 2015 Request
Lawrence Livermore National Laboratory			
Advanced Scientific Computing Research	30,107	23,135	8,090
Basic Energy Sciences	3,366	2,981	2,981
Biological and Environmental Research	17,197	16,494	16,437
Fusion Energy Sciences	9,402	7,399	8,091
High Energy Physics	2,242	1,290	1,290
Nuclear Physics	2,152	817	1,069
Workforce Development for Teachers and Scientists	195	0	0
Total, Lawrence Livermore National Laboratory	**64,661**	**52,116**	**37,958**
Los Alamos National Laboratory			
Advanced Scientific Computing Research	6,780	6,630	5,415
Basic Energy Sciences	40,276	30,516	23,425
Biological and Environmental Research	23,706	24,436	23,483
Fusion Energy Sciences	4,512	2,280	2,332
High Energy Physics	3,370	1,725	1,725
Nuclear Physics	9,513	8,419	8,419
Workforce Development for Teachers and Scientists	316	0	0
Total, Los Alamos National Laboratory	**88,473**	**74,006**	**64,799**
National Renewable Energy Laboratory			
Advanced Scientific Computing Research	186	266	186
Basic Energy Sciences	14,718	8,375	8,375
Biological and Environmental Research	1,064	932	779
Workforce Development for Teachers and Scientists	60	0	0
Total, National Renewable Energy Laboratory	**16,028**	**9,573**	**9,340**
Nevada Operations Office			
Basic Energy Sciences	1,244	0	0
New Brunswick Laboratory			
Science Laboratories Infrastructure	900	900	1,900
Program Direction	5,860	5,463	5,789
Total, New Brunswick Laboratory	**6,760**	**6,363**	**7,689**
Oak Ridge Institute for Science and Education			
Basic Energy Sciences	1,556	1,500	1,500
Biological and Environmental Research	3,786	2,050	2,463
Fusion Energy Sciences	672	644	444
High Energy Physics	1,425	0	0
Nuclear Physics	1,092	745	757
Workforce Development for Teachers and Scientists	9,208	0	0
Science Laboratories Infrastructure	0	0	1,000
Safeguards and Security	1,562	1,645	1,645
Total, Oak Ridge Institute for Science and Education	**19,301**	**6,584**	**7,809**

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Science	FY 2013 Current	FY 2014 Appropriation	FY 2015 Request
Oak Ridge National Laboratory			
Advanced Scientific Computing Research	94,272	77,610	112,054
Basic Energy Sciences	306,934	291,755	302,549
Biological and Environmental Research	76,875	76,520	79,135
Fusion Energy Sciences	144,019	212,136	163,829
High Energy Physics	50	150	150
Nuclear Physics	24,732	16,404	16,364
Safeguards and Security	9,003	9,016	9,016
Total, Oak Ridge National Laboratory	**655,885**	**683,591**	**683,097**
Oak Ridge National Laboratory Site Office			
Program Direction	5,820	5,969	6,296
Oak Ridge Office			
Advanced Scientific Computing Research	273	0	0
Basic Energy Sciences	799	0	0
Biological and Environmental Research	268	0	0
Fusion Energy Sciences	174	0	0
High Energy Physics	645	0	0
Nuclear Physics	464	0	0
Science Laboratories Infrastructure	5,734	5,751	5,777
Safeguards and Security	19,394	20,314	21,491
Program Direction	31,859	30,064	30,193
Small Business Innovative Research	500	0	0
Total, Oak Ridge Office	**60,110**	**56,129**	**57,461**
Office of Science and Technical Information			
Advanced Scientific Computing Research	132	135	132
Basic Energy Sciences	132	45	45
Biological and Environmental Research	199	202	202
Fusion Energy Sciences	132	0	0
High Energy Physics	136	124	124
Nuclear Physics	153	135	0
Workforce Development for Teachers and Scientists	248	0	0
Science Laboratories Infrastructure	200	200	200
Safeguards and Security	472	497	497
Program Direction	8,304	8,431	8,652
Total, Office of Science and Technical Information	**10,108**	**9,769**	**9,852**

Department of Energy
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($K)

Science	FY 2013 Current	FY 2014 Appropriation	FY 2015 Request
Pacific Northwest National Laboratory			
Advanced Scientific Computing Research	6,860	3,418	4,705
Basic Energy Sciences	27,611	19,607	20,333
Biological and Environmental Research	111,532	107,872	107,548
Fusion Energy Sciences	1,906	1,735	1,313
High Energy Physics	6,040	9,060	2,030
Nuclear Physics	100	100	83
Workforce Development for Teachers and Scientists	1,031	0	0
Safeguards and Security	10,742	10,965	11,317
Total, Pacific Northwest National Laboratory	**165,822**	**152,757**	**147,329**
Pacific Northwest Site Office			
Program Direction	4,871	4,911	4,903
Princeton Plasma Physics Laboratory			
Advanced Scientific Computing Research	143	143	70
Fusion Energy Sciences	72,562	74,664	71,968
High Energy Physics	225	230	230
Workforce Development for Teachers and Scientists	186	0	0
Science Laboratories Infrastructure	0	0	25,000
Safeguards and Security	2,222	2,387	2,232
Total, Princeton Plasma Physics Laboratory	**75,338**	**77,424**	**99,500**
Princeton Site Office			
Program Direction	1,591	1,548	1,633
Sandia National Laboratories			
Advanced Scientific Computing Research	13,827	11,444	9,858
Basic Energy Sciences	42,352	30,390	31,584
Biological and Environmental Research	7,537	7,919	7,536
Fusion Energy Sciences	1,837	1,613	2,155
Total, Sandia National Laboratories	**65,553**	**51,366**	**51,133**
Savannah River National Laboratory			
Basic Energy Sciences	530	409	409
Biological and Environmental Research	318	221	0
Workforce Development for Teachers and Scientists	2	0	0
Total, Savannah River National Laboratory	**850**	**630**	**409**

Department of Energy
FY 2015 Congressional Budget
Funding By Appropriation By Site
($K)

Science	**FY 2013 Current**	**FY 2014 Appropriation**	**FY 2015 Request**
SLAC National Accelerator Laboratory			
Advanced Scientific Computing Research	140	140	0
Basic Energy Sciences	207,296	272,390	342,314
Biological and Environmental Research	4,534	4,575	4,725
Fusion Energy Sciences	1,255	2,000	4,250
High Energy Physics	77,971	90,506	95,807
Nuclear Physics	83	0	0
Workforce Development for Teachers and Scientists	175	0	0
Science Laboratories Infrastructure	50,894	25,482	24,810
Safeguards and Security	2,597	2,972	2,677
Total, SLAC National Accelerator Laboratory	**344,945**	**398,065**	**474,583**
SLAC Site Office			
Program Direction	2,457	2,327	2,480
Thomas Jefferson National Accelerator Facility			
Advanced Scientific Computing Research	29	29	29
Basic Energy Sciences	500	500	500
Biological and Environmental Research	528	455	0
High Energy Physics	915	100	100
Nuclear Physics	130,941	131,237	123,025
Workforce Development for Teachers and Scientists	285	0	0
Science Laboratories Infrastructure	0	29,200	0
Safeguards and Security	1,398	1,625	1,446
Total, Thomas Jefferson National Accelerator Facility	**134,596**	**163,146**	**125,100**
Thomas Jefferson Site Office			
Program Direction	1,758	1,878	1,976
Washington Headquarters			
Advanced Scientific Computing Research	1,116	140,977	170,729
Basic Energy Sciences	2,698	152,316	173,815
Biological and Environmental Research	1,972	77,494	138,097
Fusion Energy Sciences	1,005	69,697	42,249
High Energy Physics	2,596	62,955	63,164
Nuclear Physics	19,916	55,461	55,937
Workforce Development for Teachers and Scientists	30	26,500	19,500
Safeguards and Security	1,210	6,763	13,265
Program Direction	70,972	83,631	85,187
Small Business Innovative Research	951	0	0
Total, Washington Headquarters	**102,466**	**675,794**	**761,943**
Total, Science	**4,681,195**	**5,066,372**	**5,111,155**

Advanced Research Projects Agency-Energy

Advanced Research Projects Agency-Energy

FY 2015 Congressional Budget

Advanced Research Projects Agency – Energy (ARPA-E)

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Advanced Research Projects Agency - Energy
Proposed Appropriation Language

For necessary expenses in carrying out the activities authorized by section 5012 of the America COMPETES Act (Public Law 110-69), as amended, [$280,000,000] *$325,000,000*, to remain available until expended: Provided, That [$28,000,000] *$29,250,000* shall be available until September 30, [2015] *2016* for program direction.

Explanation of Changes

No Change

Public Law Authorizations
P.L. 95-91, "Department of Energy Organization Act" (1977)
P.L. 109-58, "Energy Policy Act of 2005"
P.L. 110-69, "America COMPETES Act of 2007"
P.L. 111-358, "America COMPETES Reauthorization Act of 2010"

Advanced Research Projects Agency - Energy

($K)

FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request
250,636	280,000	280,000	325,000

Overview

The Advanced Research Projects Agency – Energy (ARPA-E) mission is to enhance the economic and energy security of the United States through the development of energy technologies that result in reductions of imports of energy from foreign sources; reductions of energy-related emissions, including greenhouse gases; and improvement in the energy efficiency of all economic sectors; and to ensure that the United States maintains a technological lead in developing and deploying advanced energy technologies.

ARPA-E catalyzes transformational energy technologies that could create a more secure and affordable American future by advancing high-potential, high-impact energy technologies that are too early for private sector investment. ARPA-E focuses on energy technologies that can be meaningfully advanced with a small investment over a defined period of time in areas that are not funded elsewhere due to high technical and financial uncertainty. ARPA-E's rigorous program design includes close coordination with other DOE and federal programs, a competitive project selection process, and hands-on engagement, thereby leading to thoughtful expenditures while empowering America's energy researchers with funding, technical assistance, and market awareness.

Since its inception in 2007, ARPA-E has invested in 362 projects, across 39 states, with over $900 million in funding. These projects have been selected through 18 focused programs and 2 open solicitations. Approximately 32% of projects are led by small business, 42% by universities, 14% by large businesses, 8% by federally funded research and development centers, and 4% by non-profits.

Highlights and Major Changes in the FY 2015 Budget Request

In FY 2015 ARPA-E expects to release a third "open" funding opportunity announcement (FOA) as well as 4 - 5 "focused" programs. Focused programs will continue to identify gaps where high-impact, high-potential investment by ARPA-E could lead to transformational technologies, developing entirely new ways to generate, store, and use energy. Following a pilot in FY2014, ARPA-E may also use a small rolling open solicitation to rapidly support innovative applied energy research that has the potential to lead to new focused programs. ARPA-E also will continue its stand-alone Small Business Innovation Research / Small Business Technology Transfer (SBIR/STTR) program to provide additional support to small businesses beyond the significant number of awards that go to small businesses via the standard FOA process.

Advanced Research Projects Agency - Energy
Funding by Congressional Control ($K)

	FY 2013 Current	FY 2014 Enacted	FY 2014 Adjustments	FY 2014 Current	FY 2015 Request	FY 2015 vs FY 2014 Enacted
ARPA-E Projects	226,647	252,000	0	252,000	295,750	43,750
Program Direction	23,989	28,000	0	28,000	29,250	1,250
Total, Advanced Research Projects Agency - Energy	**250,636**	**280,000**	**0**	**280,000**	**325,000**	**45,000**
Federal FTEs	**34**	**47**	**0**	**47**	**54**	**+7**

SBIR/STTR:
- FY 2013 Transferred: $6,914,588 total (SBIR $6,121,111 / STTR $793,477)
- FY 2014Estimate: $8,064,000 total (SBIR $7,056,000 / STTR $1,008,000)
- FY 2015 Request: $9,759,750 total (SBIR $8,576,750 / STTR $1,183,000)

ARPA-E Projects

Overview

ARPA-E has created a nimble and adaptive structure that allows the Agency to quickly develop and execute programs, recruit a highly talented and experienced technical team, and provide awardees with technical assistance and market awareness to help projects succeed.

ARPA-E “focused” programs provide a unique bridge from basic science to early stage technology. These programs draw from the latest scientific discoveries and envision a viable path to commercial implementation through firm grounding in the economic realities and changing dynamics of the marketplace. For example, in FY 2012, ARPA-E developed the Methane Opportunities for Vehicular Energy (MOVE) program to advance technologies to use abundant domestic natural gas as fuel for passenger vehicles, and in FY 2011, developed the Rare Earth Alternatives in Critical Technologies (REACT) program as a rapid response to the disruption in the rare earth supply chain.

The concept for a new focused program is developed through engagement with diverse science and technology communities, including some that may not have traditionally been involved in the topic area, and by learning from the outcomes of current ARPA-E programs and projects. For example, the FY 2013 Strategies for Wide-Bandgap, Inexpensive Transistors for Controlling High-Efficiency Systems (SWITCHES) program was influenced by breakthroughs in the area of wide-bandgap semiconductor technology from the Agile Delivery of Electrical Power Technology (ADEPT) program from FY 2011. The program development cycle also involves careful coordination with ongoing research and development efforts in other Department of Energy program offices and industry. The new Reliable Electricity Based on Electrochemical Systems (REBELS) program, which is aimed at developing fuel cell technology for distributed power generation, has been closely coordinated with other Department of Energy elements working on fuel cell technology, along with the work of industry stakeholders. In addition, the FY 2011 Green Electricity Network Integration (GENI) program is modernizing the way electricity is transmitted and, has been closely coordinated with other Department of Energy offices working on grid modernization, along with the work of industry stakeholders.

The ARPA-E focused program development cycle identifies gaps where high-impact, high-potential investment could lead to transformational technologies, developing entirely new ways to generate, store, and use energy. New programs are carefully constructed by Program Directors, and every aspect of a proposed program is intensely scrutinized for technical and economic viability as well as relevance to ARPA-E’s mission.

ARPA-E also ensures that potentially transformational ideas not within the scope of existing focused programs are not lost by utilizing “open” funding opportunity announcements. Projects selected under the open solicitations pursue novel approaches to energy innovation and work to meet technical needs not addressed by other parts of ARPA-E, other Department of Energy program offices, other government agencies, or the private sector.

Each ARPA-E project includes clearly defined technical and commercial milestones that awardees are required to meet throughout the life of a project. Program Directors work closely with each awardee, through regular meetings and onsite visits, to ensure that milestones are being achieved in a timely fashion. When a project is not achieving the goals of the program, ARPA-E works with the awardee to rectify the issue or, in cases where the issue cannot be corrected, ARPA-E discontinues funding for the project. To ensure the efficiency of ARPA-E’s hands-on engagement with awardees, ARPA-E has in-house legal, procurement, and contracting staff co-located with the Program Directors to provide direct access and timely communication.

The final element of the ARPA-E model is the Technology-to-Market program. Awardees are required to provide a Technology-to-Market plan prior to receiving an award and work closely with ARPA-E’s Technology-to-Market advisors throughout the project, to develop custom strategies, including practical training and critical business information to equip projects with a clear understanding of market needs to guide technical development. In addition, ARPA-E facilitates relationships with investors, government agencies, small and large companies, and other organizations that are necessary to move awardees to the next stage of their project development.

Highlights of Recent Programs
In FY 2013 and to date in FY 2014, ARPA-E has announced seven solicitations to fund innovative energy technologies, including a dedicated SBIR/STTR program in connection with a new focused program, and one rolling solicitation open to all technology areas that will run as a pilot program through FY 2014.

- **Robust Affordable Next Generation Energy Storage Systems (RANGE):** This program aims to accelerate widespread EV adoption by dramatically improving driving range and reliability, and by providing low-cost, low-carbon alternatives to today's vehicles. RANGE seeks to re-envision the total EV battery system rather than working to increase the energy density of individual battery cells. Some of the projects selected will focus on developing robust battery chemistries and architectures that would improve vehicle driving range and overall battery robustness. RANGE projects will also focus on multifunctional energy storage designs that use these robust storage systems to simultaneously serve other functions in a vehicle, further reducing an energy storage system's effective and overall EV weight. ARPA-E has announced 22 projects across 15 states will receive a total of $36 million under the RANGE program.

- **Reducing Emissions Using Methanotrophic Organisms for Transportation Energy (REMOTE):** REMOTE will develop transformational biological technologies to convert gas to liquids (GTL) for transportation fuels. This program aims to lower the cost of GTL conversion while enabling the use of low-cost, domestically sourced natural gas for transportation, which could reduce vehicle emissions compared to conventional gasoline engines. Using unique biological conversion methods, REMOTE will develop innovative catalysts and lab-scale reactors for efficient and cost-effective natural gas conversion. Current GTL approaches are technologically complex and require large, capital-intensive facilities, which limit widespread adoption. ARPA-E has announced 15 projects across 9 states will receive a total of $34 million under the REMOTE program.

- **Modern Electro/Thermochemical Advances in Light-Metal Systems (METALS):** METALS will develop innovative technologies for cost-effective processing and recycling of Aluminum, Magnesium and Titanium. These metals have high strength-to-weight ratios that make them ideal for creating lighter vehicles that can save fuel and reduce carbon emissions. Utilizing domestically available ores and reducing energy inputs and emissions from processing can make light metals cost competitive with current materials such as steel. METALS will also develop technologies for rapid and efficient light metal sorting to enable domestic recycling. ARPA-E has announced 18 projects across 14 states will receive a total of $32 million under the METALS program.

- **Strategies for Wide-Bandgap, Inexpensive Transistors for Controlling High-Efficiency Systems (SWITCHES) (SBIR/STTR):** SWITCHES will develop next-generation power conversion devices with the potential to transform how power is controlled and converted throughout the grid. SWITCHES will create innovative new wide-bandgap semiconductor materials, device architectures, and fabrication processes to enable increased energy density and switching frequencies, enhanced temperature control, and reduced power losses in a range of power electronics applications for electric motor drives and power switching devices for the grid. Because ARPA-E anticipated that a large number of applicants in this technology would be academia and non-SBIR/STTR eligible companies, ARPA-E issued the SWITCHES solicitation in tandem with an SBIR/STTR solicitation. ARPA-E has announced 14 projects across 9 states will receive a total of $27 million under the SWITCHES and SBIR/STTR programs.

- **Full-Spectrum Optimized Conversion and Utilization of Sunlight (FOCUS):** FOCUS will develop new technologies that deliver cost-effective solar energy when the sun is not shining. The technologies developed will help advance solar energy beyond current photovoltaic (PV) and concentrated solar power (CSP) technologies to ensure solar power remains a consistent, cost-effective renewable energy option. This new program seeks to develop technology options to deliver low-cost, high-efficiency solar energy on demand. It aims to create hybrid solar energy systems that turn sunlight into electricity for immediate use, while also producing heat that can be stored at low cost for later conversion into electricity. These hybrid converters will use the entire solar spectrum more efficiently than PV or CSP technologies. ARPA-E has announced 12 projects across 7 states will receive a total of $30 million under the FOCUS program.

- **Innovative Development in Energy-Related Applied Science (OPEN IDEAS):** In September 2013, ARPA-E launched OPEN IDEAS, a small rolling open solicitation to allow ARPA-E to rapidly support innovative seedling research projects that have the potential to lead to new focused programs. As of February 1, 2014 ARPA-E has selected 1 project for $3.75 million under the OPEN IDEAS program.

- **Reliable Electricity Based on Electrochemical Systems (REBELS):** REBELS will develop fuel cell technology for distributed power generation to improve grid stability, increase energy security, and balance intermittent renewable technologies while reducing CO2 emissions associated with current distributed generation systems. REBELS addresses these challenges by developing innovative, low-cost distributed generation technologies using electrochemical power generation that can also act as a storage device. REBELS projects will focus on developing intermediate-temperature fuel cells through innovative designs, fuel activation approaches, and low-cost materials to facilitate widespread distributed power generation. REBELS projects also explore multi-functional fuel cell systems that can store energy like a battery or use electricity to convert natural gas to liquids. ARPA-E announced a funding opportunity of up to $30 million for REBELS.

Measuring Success

The success of ARPA-E programs and projects will ultimately be measured by impact in the marketplace. As the projects ARPA-E funds seek to create transformational energy technologies that do not exist today, ARPA-E looks at various metrics to measure progress towards eventual market adoption. The primary metrics are the individual project and program milestones, which are reviewed quarterly, while more broadly, technical success is measured by indicators such as patents and publications. Most importantly, ARPA-E gauges success by project handoffs, including the formation of new companies and fostering public and private partnerships to ensure projects continue to move towards the market, as well as formation of new communities. To date, 22 ARPA-E projects have attracted more than $625 million in private-sector follow-on funding after ARPA-E's investment of approximately $95 million. In addition, at least 24 ARPA-E project teams have formed new companies to advance their technologies, more than 16 ARPA-E projects have partnered with other government agencies for further development, and at least 4 technologies funded by ARPA-E are in preliminary commercial sales.

Highlights of the FY 2015 Budget Request

In FY 2015, ARPA-E plans to release an open funding opportunity announcement (FOA) for approximately $150 million. Building on ARPA-E's two previous open funding solicitations, in FY 2009 and FY 2012, the OPEN 2015 solicitation would be designed to catalyze transformational breakthroughs across the entire spectrum of energy technologies. With the remaining requested funds beyond an OPEN FOA, ARPA-E plans to release an additional 4 – 5 focused programs, and, if the FY 2014 pilot is successful, ARPA-E plans to continue its rolling open solicitation (IDEAS). ARPA-E will also continue its stand-alone SBIR/STTR program to provide additional support to small businesses beyond the large number of awards that go to small businesses via the standard FOA process. ARPA-E will continue to employ two primary thrusts in its research portfolio: Transportation Systems and Stationary Power Systems. The ARPA-E program development model makes it impossible to predict in detail the specific focused programs that will be established in FY 2015 or the awards that will be made under OPEN 2015. The exact allocations will be determined when the FY 2015 focused programs are developed.

Strategic Vision Report

In accordance with the America COMPETES Act, Public Law 110-69, section 5012(g)(2)(2007) as amended, which has been codified as 42 U.S.C. § 16538 (h)(2), ARPA-E''s Strategic Vision Report can be found at http://arpa-e.energy.gov/sites/default/files/ARPA-E_Strategic_Vision_Report_101713.pdf.

ARPA-E Projects
Funding ($K)

	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs FY 2014 Enacted
ARPA-E Projects					
Transportation Systems	**123,311**	**100,800**	**100,800**	**147,875**	**47,075**
Stationary Power Systems	**103,336**	**151,200**	**151,200**	**147,875**	**-3,325**
Total, ARPA-E Projects	**226,647**	**252,000**	**252,000**	**295,750**	**43,750**

SBIR/STTR:

- FY 2013: Transferred $6,914,588 total (SBIR $6,212,111 / STTR $793,477)
- FY 2014Estimate: $8,064,000 total (SBIR $7,056,000 / STTR $1,008,000)
- FY 2015 Request: $9,759,750 total (SBIR $8,576,750 / STTR $1,183,000)

ARPA-E Projects
Explanation of Major Changes ($K)

	FY 2015 vs FY 2014 Enacted
ARPA-E plans to release an open funding solicitation in FY 2015 for $150 million and, assuming successful piloting in FY 2014, plans to continue its rolling open solicitation (IDEAS). In addition, ARPA-E plans to release 4 – 5 focused program solicitations. Finally, ARPA-E will continue its stand-alone SBIR/STTR program and may issue a solicitation in conjunction with an appropriate focused program.	**+43,750**
Total, ARPA-E Projects	**+43,750**

ARPA-E Projects

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
In FY 2014, the following programs have been initiated (described in more detail above): • Strategies for Wide-Bandgap, Inexpensive Transistors for Controlling High-Efficiency Systems (SWITCHES) (SBIR/STTR) • Innovative Development in Energy-Related Applied Science (OPEN IDEAS) • Reliable Electricity Based on Electrochemical Systems (REBELS) The ARPA-E technology acceleration model seeks to identify new and timely opportunities. Specific funding opportunity announcements (FOAs) are informed via a collaborative approach between ARPA-E and the technical community. ARPA-E has conducted workshops in the following areas: methane sensing for quantifying and/or mitigating emissions from natural gas production and transmission systems; low-cost drivers and targets for thermonuclear fusion; and localized thermal management for reduced energy consumption in buildings. In addition, ARPA-E is considering additional programs in the broad thematic areas of alternative transportation fuels, energy materials and processes, energy storage, and the intersection of energy and information technologies. These include the use of modern information tools to optimize the transportation network, enhanced efficiency and cleanliness of small engine technology for distributed	ARPA-E anticipates new programs in both Transportation Systems and Stationary Power Systems in one or more of the following areas: **Transportation Fuels:** The utility and energy storage capacity of liquid fuels suggest that they will remain in our transportation infrastructure for years to come. The challenge lies in finding innovative ways to produce fuels from an ever increasing variety of feedstocks. Novel routes to create fuels from carbon-neutral feedstocks (biomass or carbon dioxide) offer the potential for transformative reductions in greenhouse gas emissions associated with transportation. ARPA-E will continue to use advances in bio-engineering and biochemistry to develop photosynthetic and non-photosynthetic routes to carbon-neutral fuels. **Energy Materials and Processes:** Advanced materials are central to the development of innovative energy conversion processes that improve efficiency in the generation and use of energy, with concomitant reduction in greenhouse gas emissions. ARPA-E will continue to build upon new discoveries in fundamental material science to develop a broad range of materials for energy: catalysts, photovoltaics, structural materials, thermoelectrics, intelligent materials, semiconductors, magnetic materials, membranes, and others. Many of these new materials are well tailored for specific function at the nanoscale level, but pathways for their cost-effective manufacture at the scale needed for energy technology does not yet exist. ARPA-E will continue to invest in research and development devoted to moving nanoscale materials from the realm of scientific discovery into real-world processes for improved energy utilization in a variety of technologies, including engines, heating and air conditioning units, electric motors, power electronics, solar cells, wind turbines, and other technologies that are only beginning to be envisioned for energy applications. **Energy Storage:** Effective, inexpensive, reversible conversion of	ARPA-E fully funds projects at the time of award. This will enable ARPA-E, as in prior fiscal years, to use FY 2015 funding mainly for new programs and projects. A portion of FY 2015 funding may be used to supplement ongoing ARPA-E projects for which a small amount of additional funding from ARPA-E could catalyze a substantial technological development, leading to future support from outside ARPA-E that will help advanced the technology towards the market.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
power generation, the development of technologies to maximize energy crop production while minimizing water and fertilizer usage, improved thermal management in stationary power generation to minimize water usage, further development of algorithms and control technologies for power grids at various scales of distribution, and the application of nanoscale photonic technologies to the conversion of solar energy to electricity.	electrical energy to a more easily stored form, such as chemical, mechanical, and thermal energy, remains a central challenge to the widespread adoption of electric vehicles and the increased penetration of intermittent renewable energy sources onto the electric grid. ARPA-E plans to build upon previous investments in electrical energy storage for both transportation and the grid. These programs have built new communities of scientists and engineers that are approaching the challenge of energy storage in new and exciting ways. Moreover, these projects exhibit an amplification of learning through crossovers between programs. Because of these new insights, ARPA-E continues to envision new technology approaches as well as additional areas where efficient and inexpensive energy storage technologies are required. **Sensors, Information, and Integration:** As energy technology meets the information age, the need to collect, analyze, standardize, and protect energy information will grow and diversify over many energy systems. The transition to smart and resilient energy systems will be enabled by reliable and inexpensive sensors to provide essential data, analytical tools capable of dealing with the vast amounts of data created, and sophisticated control algorithms to optimize system performance. ARPA-E has invested in building the innovative new components that need to be integrated into larger systems to achieve full impact and now sees a broad opportunity in the combination of sensor technology, informatics, and system integration. ARPA-E currently invests in the development of advanced sensors and control technologies for battery management and control algorithms for the power grid. ARPA-E plans to explore the further development of hardware and software tools needed to characterize, optimize, and control additional smart, integrated energy systems of the future. Future investments in systems integration will not replicate scale-up and manufacturing issues that are best addressed by the Department of Energy applied technology programs or private industry.	

ARPA-E Projects
Performance Measures

In accordance with the GPRA Modernization Act of 2010, the Department sets targets for, and tracks progress toward, achieving performance goals for each program. For more information, refer to the Department's FY 2013 Annual Performance Report.

	FY 2013	FY 2014	FY 2015
Performance Goal (Measure)	**Award Funding** - Cumulative percentage of award funding committed 45 days after award selections are announced		
Target	70%	70%	
Result	Met		
Endpoint Target	No endpoint - continuous measure of efficiency in awarding funds		
Performance Goal (Measure)	**New Company Formation** – Number of new companies formed as a direct result of ARPA-E funding. This is a new performance measure for ARPA-E in FY 2015. As of the end of FY 2013 ARPA-E funded research has led to the formation of at least 24 new companies. That is the baseline from which we would expect to add at least 3 new companies per year.		
Target	N/A	≥+3	≥+3
Result	N/A		
Endpoint Target	No endpoint – continuous measure of impact of ARPA-E awards on creating new jobs and industries		

Program Direction

Overview
Program direction provides ARPA-E with the necessary resources to execute ARPA-E's mission. Program direction funds are utilized for salaries and benefits of federal staff; travel; support services contracts to provide technical advisory and assistance services; and other related expenses, including the DOE Working Capital Fund.

The core of the ARPA-E model is the team, particularly the Agency's Program Directors and Technology-to-Market advisors. ARPA-E Program Directors provide awardees with technical guidance that combines scientific expertise and real-world experience and ARPA-E Technology-to-Market advisors supply critical business insight and direction to enable awardees to develop strategies to move technologies towards the market. The ARPA-E team manages awards through hands-on engagement with awardees to ensure thoughtful expenditures while empowering America's energy researchers with funding, technical assistance, and market awareness. Part of the ARPA-E model is to utilize technical contractor support, which enables ARPA-E to rapidly move into new technology areas in response to scientific discoveries, breakthroughs, and opportunities. Each ARPA-E project includes clearly defined technical and commercial milestones that awardees are required to meet throughout the life of a project. When a project is not achieving the goals of the program, ARPA-E works with the awardee to rectify the issue or, in cases where the issue cannot be corrected, ARPA-E discontinues funding for the project. To ensure the efficiency of ARPA-E's hands on engagement with awardees, ARPA-E has in-house legal, procurement, and contracting staff co-located with the Program Directors to provide direct access and timely communication.

Highlights of the FY 2015 Budget Request
ARPA-E Program Directors serve limited terms. The request therefore supports recruitment of sufficient program direction staff to manage ARPA-E programs funded in FY 2015. The increase in program funding will require an increase in staff to provide quality program oversight. In addition, ARPA-E will continue to build its Technology-to-Market team to ensure that appropriate resources are available to work closely with all ARPA-E awardees. Starting in FY 2014, ARPA-E's program direction funds will also support embedded procurement staff; the costs of which are included in the FY 2015 request.

Program Direction
Funding ($K)

	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs FY 2014 Enacted
Program Direction Summary					
Washington Headquarters					
Salaries and Benefits	5,264	8,880	8,880	9,696	816
Travel	950	1,003	1,003	1,316	313
Support Services	13,821	13,330	13,330	13,163	-167
Other Related Expenses	3,954	4,787	4,787	5,075	288
Total, Washington Headquarters	**23,989**	**28,000**	**28,000**	**29,250**	**1,250**
Federal FTEs	**34**	**49**	**49**	**56**	**7**

Support Services and Other Related Expenses

	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs FY 2014 Enacted
Support Services					
Technical Support	4,837	4,665	4,665	4,607	-58
Management Support	8,984	8,665	8,665	8,556	-109
Total, Support Services	**13,821**	**13,330**	**13,330**	**13,163**	**-167**
Other Related Expenses					
Rental payments to GSA	1,987	2,202	2,202	2,283	81
Communications, utilities, and misc. charges	450	500	500	550	50
Printing and reproduction	10	10	10	10	0
Other services from non-Federal sources	440	465	465	475	10
Other goods and services from Federal sources	970	1,510	1,510	1,652	142
Supplies and materials	97	100	100	105	5
Total, Other Related Expenses	**3,954**	**4,787**	**4,787**	**5,075**	**288**

Program Direction

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
Salaries and Benefits		
At the FY 2014 enacted level ARPA-E anticipates needing up to 49 Federal FTEs. This includes the addition of about 8 procurement staff previously provided to ARPA-E by DOE Headquarters Procurement at no cost to ARPA-E, an additional 3 Program Directors, and 4 Technology-to-Market advisers. The number of Federal FTEs in FY 2014 is commensurate to the number of ongoing and anticipated projects.	At the FY 2015 request level ARPA-E anticipates needing up to 56 Federal FTEs.	The increase in funding and FTEs support the additional staff required to develop new programs and manage a larger number of projects.
Travel		
ARPA-E Program Directors and Technology-to-Market advisers visit performers regularly as part of ARPA-E's hands-on engagement; which is the primary component of ARPA-E travel. The amount of site visits is commensurate with the number of ongoing projects. In FY 2014 ARPA-E anticipates the number of active projects will continue to grow.	At the FY 2015 request level ARPA-E anticipates the number of active projects will continue to grow.	The FY 2015 request for travel is based on actual travel costs in FY 2013, and the projected number of projects that will be ongoing and started in FY 2014 and FY 2015.
Support Services		
The FY 2014 enacted level for support services reflects the estimated costs for the type of support service contractors appropriate to support ARPA-E federal staff in ensuring management and oversight of ARPA-E projects and other required functions. The level of support by contractors is commensurate to the number of ongoing and anticipated projects.	At the FY 2015 request level ARPA-E anticipates a continued level of support commensurate to the number of ongoing and anticipated projects.	ARPA-E will continue to optimize federal staff and contractor support based on funding levels and the number of projects under management.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
Other Related Expenses		
The FY 2014 enacted level for other related expenses reflects the anticipated costs of these activities for the fiscal year.	In FY 2015 ARPA-E is requesting $5,075,000 for other related expenses.	The primary drivers of the Other Related costs are the Working Capital Fund and Information Technology support resulting from the increase in staffing levels, and funding for the National Academies of Science study required by P.L. 110-69 "America COMPETES Act of 2007", as amended by P.L. 111-358, "America COMPETES Reauthorization Act of 2010".

Advanced Research Projects Agency - Energy
Research and Development ($K)

	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs FY 2014 Enacted
Basic	0	0	0	0	0
Applied	111,605	126,000	126,000	147,875	21,875
Development	115,042	126,000	126,000	147,875	21,875
Subtotal, R&D	226,647	252,000	252,000	295,750	43,750
Equipment	0	0	0	0	0
Construction	0	0	0	0	0
Total, R&D	**226,647**	**252,000**	**252,000**	**295,750**	**43,750**

Advanced Research Projects Agency - Energy
Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR) ($K)

	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request[1]	FY 2015 vs FY 2014 Enacted
ARPA-E Projects					
SBIR	6,121	7,056	7,056	8,576	1,520
STTR	793	1,008	1,008	1,183	175
Total, SBIR/STTR	**6,914**	**8,064**	**8,064**	**9,759**	**1,695**

[1] In FY 2015, ARPA-E plans to continue its stand-alone SBIR/STTR program to provide additional support to small businesses beyond the large number of awards that go to small businesses via the standard Funding Opportunity Announcement process.

Department Of Energy
FY 2015 Congressional Budget
Funding By Appropriation By Site
($K)

Advanced Researched Projects Agency-Energy	FY 2013 Current	FY 2014 Enacted	FY 2015 Request
Washington Headquarters			
Energy Transformation Acceleration Fund			
Advanced Research Projects Agency-Energy	226,647	252,000	295,750
Program Direction	23,989	28,000	29,250
Total, Energy Transformation Acceleration Fund	**250,636**	**280,000**	**325,000**
Total, Washington Headquarters	**250,636**	**280,000**	**325,000**
Total, Advanced Researched Projects Agency-Energy	**250,636**	**280,000**	**325,000**

GENERAL PROVISIONS – DEPARTMENT OF ENERGY
(INCLUDING TRANSFER OF FUNDS)

[SEC. 301. (a) No appropriation, funds, or authority made available by this title for the Department of Energy shall be used to initiate or resume any program, project, or activity or to prepare or initiate Requests For Proposals or similar arrangements (including Requests for Quotations, Requests for Information, and Funding Opportunity Announcements) for a program, project, or activity if the program, project, or activity has not been funded by Congress.

(b)(1) Unless the Secretary of Energy notifies the Committees on Appropriations of the House of Representatives and the Senate at least 3 full business days in advance, none of the funds made available in this title may be used to—

(A) make a grant allocation or discretionary grant award totaling $1,000,000 or more;

(B) make a discretionary contract award or Other Transaction Agreement totaling $1,000,000 or more, including a contract covered by the Federal Acquisition Regulation;

(C) issue a letter of intent to make an allocation, award, or Agreement in excess of the limits in subparagraph (A) or (B); or

(D) announce publicly the intention to make an allocation, award, or Agreement in excess of the limits in subparagraph (A) or (B).

(2) The Secretary of Energy shall submit to the Committees on Appropriations of the House of Representatives and the Senate within 15 days of the conclusion of each quarter a report detailing each grant allocation or discretionary grant award totaling less than $1,000,000 provided during the previous quarter.

(3) The notification required by paragraph (1) and the report required by paragraph (2) shall include the recipient of the award, the amount of the award, the fiscal year for which the funds for the award were appropriated, the account and program, project, or activity from which the funds are being drawn, the title of the award, and a brief description of the activity for which the award is made.

(c) The Department of Energy may not, with respect to any program, project, or activity that uses budget authority made available in this title under the heading "Department of Energy—Energy Programs", enter into a multiyear contract, award a multiyear grant, or enter into a multiyear cooperative agreement unless—

(1) the contract, grant, or cooperative agreement is funded for the full period of performance as anticipated at the time of award; or

(2) the contract, grant, or cooperative agreement includes a clause conditioning the Federal Government's obligation on the availability of future year budget authority and the Secretary notifies the Committees on Appropriations of the House of Representatives and the Senate at least 3 days in advance.

(d) Except as provided in subsections (e), (f), and (g), the amounts made available by this title shall be expended as authorized by law for the programs, projects, and activities specified in the "Final Bill" column in the "Department of Energy" table included under the heading "Title III—Department of Energy" in the explanatory statement described in section 4 (in the matter preceding division A of this consolidated Act).

(e) The amounts made available by this title may be reprogrammed for any program, project, or activity, and the Department shall notify the Committees on Appropriations of the House of Representatives and the Senate at least 30 days prior to the use of any proposed reprogramming which would cause any program, project, or activity funding level to increase or decrease by more than $5,000,000 or 10 percent, whichever is less, during the time period covered by this Act.

(f) None of the funds provided in this title shall be available for obligation or expenditure through a reprogramming of funds that—

(1) creates, initiates, or eliminates a program, project, or activity;

(2) increases funds or personnel for any program, project, or activity for which funds are denied or restricted by this Act; or

(3) reduces funds that are directed to be used for a specific program, project, or activity by this Act.

(g)(1) The Secretary of Energy may waive any requirement or restriction in this section that applies to the use of funds made available for the Department of Energy if compliance with such requirement or restriction would pose a substantial risk to human health, the environment, welfare, or national security.

(2) The Secretary of Energy shall notify the Committees on Appropriations of the House of Representatives and the Senate of any waiver under paragraph (1) as soon as practicable, but not later than 3 days after the date of the activity to which a requirement or restriction would otherwise have applied. Such notice shall include an explanation of the substantial risk under paragraph (1) that permitted such waiver.**]**

SEC. **[**302**]***301*. The unexpended balances of prior appropriations provided for activities in this Act may be available to the same appropriation accounts for such activities established pursuant to this title. Available balances may be merged with funds in the applicable established accounts and thereafter may be accounted for as one fund for the same time period as originally enacted.

SEC. **[**303**]***302*. Funds appropriated by this or any other Act, or made available by the transfer of funds in this Act, for intelligence activities are deemed to be specifically authorized by the Congress for purposes of section 504 of the National Security Act of 1947 (50 U.S.C. 414) during fiscal year **[**2014**]** *2015* until the enactment of the Intelligence Authorization Act for fiscal year **[**2014**]** *2015*.

SEC. **[**304**]***303*. None of the funds made available in this title shall be used for the construction of facilities classified as high-hazard nuclear facilities under 10 CFR Part 830 unless independent oversight is conducted by the Office of Health, Safety, and Security to ensure the project is in compliance with nuclear safety requirements.

SEC. **[**305**]***304*. None of the funds made available in this title may be used to approve critical decision-2 or critical decision-3 under Department of Energy Order 413.3B, or any successive departmental guidance, for construction projects where the total project cost exceeds $100,000,000, until a separate independent cost estimate has been developed for the project for that critical decision.

SEC. 305. Section 15(g) of Public Law 85–536 (15 U.S.C. 644), as amended, is further amended by striking paragraph (3).

[SEC. 306. (a) Any determination (including a determination made prior to the date of enactment of this Act) by the Secretary pursuant to section 3112(d)(2)(B) of the USEC Privatization Act (110 Stat. 1321–335), as amended, shall be valid for not more than 2 calendar years subsequent to such determination.

(b) Not less than 30 days prior to the provision of uranium in any form the Secretary shall notify the House and Senate Committees on Appropriations of the following:

(1) the amount of uranium to be provided;

(2) an estimate by the Secretary of the gross fair market value of the uranium on the expected date of the provision of the uranium;

(3) the expected date of the provision of the uranium;

(4) the recipient of the uranium; and

(5) the value the Secretary expects to receive in exchange for the uranium, including any adjustments to the gross fair market value of the uranium.**]**

[SEC. 307. Section 20320 of the Continuing Appropriations Resolution, 2007, Public Law 109–289, division B, as amended by the Revised Continuing Appropriations Resolution, 2007, Public Law 110–5, is amended by striking in subsection (c) “an annual review” after “conduct” and inserting in lieu thereof “a review every three years”.**]**

[SEC. 308. None of the funds made available by this or any subsequent Act for fiscal year 2014 or any fiscal year hereafter may be used to pay the salaries of Department of Energy employees to carry out the amendments made by section 407 of division A of the American Recovery and Reinvestment Act of 2009.**]**

SEC. **[**309**]***306*. Notwithstanding section 307 of Public Law 111–85, of the funds made available by the Department of Energy for activities at Government-owned, contractor-operated laboratories funded in this or any subsequent Energy and Water Development Appropriations Act for any fiscal year, the Secretary may authorize a specific amount, not to exceed 6 percent of such funds, to be used by such laboratories for laboratory directed research and development.

[SEC. 310. Notwithstanding section 301(c) of this Act, none of the funds made available under the heading “Department of Energy—Energy Programs—Science” may be used for a multiyear contract, grant, cooperative agreement, or Other Transaction Agreement of $1,000,000 or less unless the contract, grant, cooperative agreement, or Other Transaction Agreement is funded for the full period of performance as anticipated at the time of award.**]**

[SEC. 311. (a) Not later than June 30, 2014, the Secretary shall submit to the Committees on Appropriations of the House of Representatives and the Senate a tritium and enriched uranium management plan that provides—

(1) an assessment of the national security demand for tritium and low and highly enriched uranium through 2060;

(2) a description of the Department of Energy's plan to provide adequate amounts of tritium and enriched uranium for national security purposes through 2060; and

(3) an analysis of planned and alternative technologies which are available to meet the supply needs for tritium and

enriched uranium for national security purposes, including weapons dismantlement and down-blending.
(b) The analysis provided by (a)(3) shall include a detailed estimate of the nearand long-term costs to the Department of Energy should the Tennessee Valley Authority no longer be a viable tritium supplier.**]**

[SEC. 312. The Secretary of Energy shall submit to the congressional defense committees (as defined in U.S.C. 101(a)(16)), a report on each major warhead refurbishment program that reaches the Phase 6.3 milestone, and not later than April 1, 2014 for the B61–12 life extension program, that provides an analysis of alternatives which includes—
(1) a full description of alternatives considered prior to the award of Phase 6.3;
(2) a comparison of the costs and benefits of each of those alternatives, to include an analysis of trade-offs among cost, schedule, and performance objectives against each alternative considered;
(3) identification of the cost and risk of critical technology elements associated with each alternative, including technology maturity, integration risk, manufacturing feasibility, and demonstration needs;
(4) identification of the cost and risk of additional capital asset and infrastructure capabilities required to support production and certification of each alternative;
(5) a comparative analysis of the risks, costs, and scheduling needs for any military requirement intended to enhance warhead safety, security, or maintainability, including any requirement to consolidate and/or integrate warhead systems or mods as compared to at least one other feasible refurbishment alternative the Nuclear Weapons Council considers appropriate; and
(6) a life-cycle cost estimate for the alternative selected that details the overall cost, scope, and schedule planning assumptions. For the B61–12 life extension program, the life cycle cost estimate shall include an analysis of reduced life cycle costs for Option 3b, including cost savings from consolidating the different B61 variants.**]**

[SEC. 313. (a) IN GENERAL.—Subject to subsections (b) through (d), the Secretary may appoint, without regard to the provisions of chapter 33 of title 5, United States Code, governing appointments in the competitive service, exceptionally well qualified individuals to scientific, engineering, or other critical technical positions.
(b) LIMITATIONS.—
(1) NUMBER OF POSITIONS.—The number of critical positions authorized by subsection (a) may not exceed 120 at any one time in the Department.
(2) TERM.—The term of an appointment under subsection (a) may not exceed 4 years.
(3) PRIOR EMPLOYMENT.—An individual appointed under subsection (a) shall not have been a Department employee during the 2-year period ending on the date of appointment.
(4) PAY.—
(A) IN GENERAL.—The Secretary shall have the authority to fix the basic pay of an individual appointed under subsection (a) at a rate to be determined by the Secretary up to level I of the Executive Schedule without regard to the civil service laws.
(B) TOTAL ANNUAL COMPENSATION.—The total annual compensation for any individual appointed under subsection (a) may not exceed the highest total annual compensation payable at the rate determined under section 104 of title 3, United States Code.
(5) ADVERSE ACTIONS.—An individual appointed under subsection
(a) may not be considered to be an employee for purposes of subchapter II of chapter 75 of title 5, United States Code.
(c) REQUIREMENTS.—
(1) IN GENERAL.—The Secretary shall ensure that—
(A) the exercise of the authority granted under subsection (a) is consistent with the merit principles of section 2301 of title 5, United States Code; and
(B) the Department notifies diverse professional associations and institutions of higher education, including those serving the interests of women and racial or ethnic minorities that are underrepresented in scientific, engineering, and mathematical fields, of position openings as appropriate.
(2) REPORT.—Not later than 2 years after the date of enactment of this Act, the Secretary and the Director of the Office of Personnel Management shall submit to Congress a report on the use of the authority provided under this section that includes, at a minimum, a description or analysis of—
(A) the ability to attract exceptionally well qualified scientists, engineers, and technical personnel;
(B) the amount of total compensation paid each employee hired under the authority each calendar year; and
(C) whether additional safeguards or measures are necessary to carry out the authority and, if so, what action, if any, has been taken to implement the safeguards or measures.
(d) TERMINATION OF EFFECTIVENESS.—The authority provided by this section terminates effective on the date that is 4 years after the date of enactment of this Act.**]**

[SEC. 314. Section 804 of Public Law 110–140 (42 U.S.C. 17283) is hereby repealed.]

[SEC. 315. Section 205 of Public Law 95–91 (42 U.S.C. 7135), as amended, is hereby further amended:
(1) in paragraph (i)(1) by striking “once every two years” and inserting “once every four years”; and
(2) in paragraph (k)(1) by striking “once every three years” and inserting “once every four years”.]

[SEC. 316. Notwithstanding any other provision of law, the Department may use funds appropriated by this title to carry out a study regarding the conversion to contractor performance of any function performed by Federal employees at the New Brunswick Laboratory, pursuant to Office of Management and Budget Circular A-76 or any other administrative regulation, directive, or policy.]

[SEC. 317. Of the amounts appropriated for non-defense programs in this title, $7,000,000 are hereby reduced to reflect savings from limiting foreign travel for contractors working for the Department of Energy, consistent with similar savings achieved for Federal employees. The Department shall allocate the reduction among the non-security appropriations made in this title.]

[SEC. 318. Section 15(g) of Public Law 85–536 (15 U.S.C. 644), as amended, is hereby further amended by inserting the following at the end: “(3) First tier subcontracts that are awarded by Management and Operating contractors sponsored by the Department of Energy to small business concerns, small businesses concerns owned and controlled by service disabled veterans, qualified HUBZone small business concerns, small business concerns owned and controlled by socially and economically disadvantaged individuals, and small business concerns owned and controlled by women, shall be considered toward the annually established agency and Government-wide goals for procurement contracts awarded.”.]

[SEC. 319. (a) ESTABLISHMENT.—The Secretary shall establish an independent commission to be known as the “Commission to Review the Effectiveness of the National Energy Laboratories.” The National Energy Laboratories refers to all Department of Energy and National Nuclear Security Administration national laboratories.

(b) MEMBERS.—

(1) The Commission shall be composed of nine members who shall be appointed by the Secretary of Energy not later than May 1, 2014, from among persons nominated by the President's Council of Advisors on Science and Technology.

(2) The President's Council of Advisors on Science and Technology shall, not later than March 15, 2014, nominate not less than 18 persons for appointment to the Commission from among persons who meet qualification described in paragraph (3).

(3) Each person nominated for appointment to the Commission shall—

(A) be eminent in a field of science or engineering; and/or

(B) have expertise in managing scientific facilities; and/or

(C) have expertise in cost and/or program analysis; and

(D) have an established record of distinguished service.

(4) The membership of the Commission shall be representative of the broad range of scientific, engineering, financial, and managerial disciplines related to activities under this title.

(5) No person shall be nominated for appointment to the Board who is an employee of—

(A) the Department of Energy;

(B) a national laboratory or site under contract with the Department of Energy;

(C) a managing entity or parent company for a national laboratory or site under contract with the Department of Energy; or

(D) an entity performing scientific and engineering activities under contract with the Department of Energy.

(c) COMMISSION REVIEW AND RECOMMENDATIONS.—

(1) The Commission shall, by no later than February 1, 2015, transmit to the Secretary of Energy and the Committees on Appropriations of the House of Representatives and the Senate a report containing the Commission's findings and conclusions.

(2) The Commission shall address whether the Department of Energy's national laboratories—

(A) are properly aligned with the Department's strategic priorities; (B) have clear, well understood, and properly balanced missions that are not unnecessarily redundant and duplicative;

(C) have unique capabilities that have sufficiently evolved to meet current and future energy and national security challenges;

(D) are appropriately sized to meet the Department's energy and national security missions; and

(E) are appropriately supporting other Federal agencies and the extent to which it benefits DOE missions.

(3) The Commission shall also determine whether there are opportunities to more effectively and efficiently use the capabilities of the national laboratories, including consolidation and realignment, reducing overhead costs, reevaluating governance models using industrial and academic bench marks for comparison, and assessing the impact of DOE's oversight and management approach. In its evaluation, the Commission should also consider the cost and effectiveness of using other research, development, and technology centers and universities as an alternative to meeting DOE's energy and national security goals.

(4) The Commission shall analyze the effectiveness of the use of laboratory directed research and development (LDRD) to meet the Department of Energy's science, energy, and national security goals. The Commission shall further evaluate the effectiveness of the Department's oversight approach to ensure LDRD-funded projects are compliant with statutory requirements and congressional direction, including requirements that LDRD projects be distinct from projects directly funded by appropriations and that LDRD projects derived from the Department's national security programs support the national security mission of the Department of Energy. Finally, the Commission shall quantify the extent to which LDRD funding supports recruiting and retention of qualified staff.

(5) The Commission's charge may be modified or expanded upon approval of the Committees on Appropriations of the House of Representatives and the Senate.

(d) RESPONSE BY THE SECRETARY OF ENERGY.—

(1) The Secretary of Energy shall, by no later than April 1, 2015, transmit to Committees on Appropriations of the House of Representatives and the Senate a report containing the Secretary's approval or disapproval of the Commission's recommendations and an implementation plan for approved recommendations.**]**

[SEC. 320. The Committees on Appropriations of the House of Representatives and the Senate shall receive a 30-day advance notification with a detailed explanation of any waiver or adjustment made by the National Nuclear Security Administration's Fee Determining Official to at-risk award fees for Management and Operating contractors that result in award term extensions.**]**

[SEC. 321. To further the research, development, and demonstration of national nuclear security-related enrichment technologies, the Secretary of Energy may transfer up to $56,650,000 of funding made available in this title under the heading “National Nuclear Security Administration” to “National Nuclear Security Administration, Weapons Activities” not earlier than 30 days after the Secretary provides to the Committees on Appropriations of the House of Representatives and the Senate a cost-benefit analysis of available and prospective domestic enrichment technologies for national security needs, the scope, schedule, and cost of his preferred option, and after congressional notification and approval of the Committees on Appropriations of the House of Representatives and the Senate.**]**

[SEC. 322. None of the funds made available in this Act may be used—

(1) to implement or enforce section 430.32(x) of title 10, Code of Federal Regulations; or

(2) to implement or enforce the standards established by the tables contained in section 325(i)(1)(B) of the Energy Policy and Conservation Act (42 U.S.C. 6295(i)(1)(B)) with respect to BPAR incandescent reflector lamps, BR incandescent reflector lamps, and ER incandescent reflector lamps.**]** *(Energy and Water Development and Related Agencies Appropriations Act, 2014.)*

TITLE V—GENERAL PROVISIONS

SEC. 501. None of the funds appropriated by this Act may be used in any way, directly or indirectly, to influence congressional action on any legislation or appropriation matters pending before Congress, other than to communicate to Members of Congress as described in 18 U.S.C. 1913.

SEC. 502. None of the funds made available by this Act may be used to enter into a contract, memorandum of understanding, or cooperative agreement with, make a grant to, or provide a loan or loan guarantee to any corporation that was convicted of a felony criminal violation under any Federal law within the preceding 24 months, where the awarding agency is aware of the conviction, unless **[**the**]***a Federal* agency has considered suspension or debarment of the corporation and **[**has**]** made a determination that this further action is not necessary to protect the interests of the Government.

SEC. 503. None of the funds made available by this Act may be used to enter into a contract, memorandum of understanding, or cooperative agreement with, make a grant to, or provide a loan or loan guarantee to, any corporation that has any unpaid Federal tax liability that has been assessed, for which all judicial and administrative remedies have been exhausted or have lapsed, and that is not being paid in a timely manner pursuant to an agreement with the authority responsible for collecting the tax liability, where the awarding agency is aware of the unpaid tax liability, unless **[**the**]***a Federal* agency has considered suspension or debarment of the corporation and **[**has**]** made a determination that this further action is not necessary to protect the interests of the Government.

[SEC. 504. (a) None of the funds made available in title III of this Act may be transferred to any department, agency, or instrumentality of the United States Government, except pursuant to a transfer made by or transfer authority provided in this Act or any other appropriations Act for any fiscal year, transfer authority referenced in the explanatory statement described in section 4 (in the matter preceding division A of this consolidated Act), or any authority whereby a department, agency, or instrumentality of the United States Government may provide goods or services to another department, agency, or instrumentality.

(b) None of the funds made available for any department, agency, or instrumentality of the United States Government may be transferred to accounts funded in title III of this Act, except pursuant to a transfer made by or transfer authority provided in this Act or any other appropriations Act for any fiscal year, transfer authority referenced in the explanatory statement described in section 4 (in the matter preceding division A of this consolidated Act), or any authority whereby a department, agency, or instrumentality of the United States Government may provide goods or services to another department, agency, or instrumentality.

(c) The head of any relevant department or agency funded in this Act utilizing any transfer authority shall submit to the Committees on Appropriations of the House of Representatives and the Senate a semiannual report detailing the transfer authorities, except for any authority whereby a department, agency, or instrumentality of the United States Government may provide goods or services to another department, agency, or instrumentality, used in the previous 6 months and in the year-to-date. This report shall include the amounts transferred and the purposes for which they were transferred, and shall not replace or modify existing notification requirements for each authority.**]**

SEC. **[**505**]***504*. None of the funds made available by this Act may be used in contravention of Executive Order No. 12898 of February 11, 1994 (“Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations”).