Basic Energy Sciences
Funding Profile by Subprogram

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR*	FY 2014 Request
Materials Sciences and Engineering			
Scattering and Instrumentation Sciences Research	62,369	—	62,369
Condensed Matter and Materials Physics Research	124,629	—	124,629
Materials Discovery, Design, and Synthesis Research	73,384	—	73,384
Experimental Program to Stimulate Competitive Research (EPSCoR)	8,520	—	8,520
Energy Frontier Research Centers (EFRCs)	57,330	—	97,863
Energy Innovation Hubs—Batteries and Energy Storage	19,410	—	24,237
SBIR/STTR	0	—	12,926
Total, Materials Sciences and Engineering	345,642	—	403,928
Chemical Sciences, Geosciences, and Biosciences		—	
Fundamental Interactions Research	75,510	—	76,047
Chemical Transformations Research	94,331	—	94,553
Photochemistry and Biochemistry Research	69,114	—	69,605
Energy Frontier Research Centers (EFRCs)	42,670	—	70,866
Energy Innovation Hubs—Fuels from Sunlight	24,263	—	24,237
General Plant Projects (GPP)	2,852	—	600
SBIR/STTR	0	—	11,085
Total, Chemical Sciences, Geosciences, and Biosciences	308,740	—	346,993
Scientific User Facilities		—	
Synchrotron Radiation Light Sources	381,012	—	464,000
High-Flux Neutron Sources	249,000	—	261,490
Nanoscale Science Research Centers (NSRCs)	102,781	—	106,500
Other Project Costs	7,700	—	28,100
Major Items of Equipment	73,500	—	64,200
Research	24,992	—	36,966
SBIR/STTR	0	—	28,934
Total, Scientific User Facilities	838,985	—	990,190
Subtotal, Basic Energy Sciences	1,493,367	1,546,097	1,741,111

	FY 2012 Current	FY 2013 Annualized CR*	FY 2014 Request
	(dollars in thousands)		
Construction			
Linac Coherent Light Source-II (LCLS-II), SLAC	0	0	95,000
National Synchrotron Light Source-II (NSLS-II), BNL	151,400	152,327	26,300
Total, Construction	151,400	152,327	121,300
Total, Basic Energy Sciences[a]	1,644,767	1,698,424	1,862,411

*FY 2013 amounts shown reflect the P.L. 112-175 continuing resolution level annualized to a full year. These amounts are shown only at the "congressional control" level and above; below that level a dash (—) is shown.

[a] SBIR/STTR funding:

- FY 2012 Appropriation: SBIR $38,186,000 and STTR $5,140,000 (transferred out of BES in FY 2012 Current column)
- FY 2014 Request: SBIR $46,326,000 and STTR $6,619,000

Public Law Authorizations

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"

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 serves as an agent of change in achieving 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 scattering centers, electron beam characterization capabilities, and research centers for nanoscale science. BES facilities probe materials in space, time, and energy to interrogate the inner workings 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. These capabilities—unthinkable only a few decades ago—create unprecedented opportunities to revolutionize the discovery and design of advanced materials and novel chemical processes for advanced energy technologies that can result in broad economic and societal impacts.

As history has proven, major breakthroughs in clean energy technologies will likely be built on a deep foundation of basic research advances. Solar photovoltaic technology has its roots in Einstein's early twentieth-century paper on the photoelectric effect. The electronics used to improve the efficiency of today's internal combustion engine have their root in the transistor, whose development was enabled by the discovery of quantum mechanics. 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.

Basic and Applied R&D Coordination

As a fundamental research program within the Department of Energy, it is important to maintain strong, continual coordination activities between BES and other DOE program offices. Coordination between DOE R&D programs is achieved 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 staff participates in reviews of BES research, and BES staff participates in reviews of research funded by the technology offices and ARPA-E. In FY 2014, SC and EM will also implement new platforms for coordination such as workshops and formal technical coordination working groups, which have been used to effectively improve coordination between basic research and applied programs in DOE.

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 of resources, expertise, and knowledge of research breakthroughs and program needs. The Department's national laboratory system plays a particularly important role in this regard.

Program Accomplishments and Milestones

Versatile Material for Efficient and Low-Cost Gas Separation. Separation of natural gas for use as a fuel or as a starting material for the synthesis of high purity chemicals could be less costly and more efficient due to the discovery of a new type of hybrid material, a novel iron based metal-organic framework. The new material, which has a sponge-like framework and is primarily composed of carbon, separates gases at nearly ambient conditions and at lower pressures than current commercial processes. The discovery was based on new understanding of how the addition of iron into the structure increased the capture of relevant hydrocarbons from the gases. This material also has potential for capture of carbon dioxide from flue gas exhausts produced by fossil-fuel power plants.

Rare Earth Additions Make the Best Better. One of the best thermoelectric materials, which convert heat to electricity, is now 15% better through the addition of a small amount of a rare earth element, dysprosium. Research has shown that the dysprosium atoms distort the local crystalline lattice and enable energy carriers to move preferentially through the material, improving heat conversion to electricity. This enhanced understanding of how additions of small amounts of other elements impact thermoelectric properties will facilitate the design even better thermoelectric materials.

Predictive Design of Nanoporous Supercapacitors. New theoretical understanding and simulations are guiding the design of new supercapacitors, a type of electrochemical storage system that can potentially outperform traditional batteries by orders of magnitude. Energy storage in supercapacitors hinges on the flow of electrolyte ions through small pores; researchers have developed models that predict their performance as a function of pore size. Predictions from these new models have explained several phenomena observed in these systems. These approaches point to new ways to optimize supercapacitors, increasing their performance for future energy storage use.

Advance in Understanding Plutonium. The first nuclear magnetic resonance (NMR) signature of plutonium has been discovered, establishing a key for deciphering the complex properties of this important element. Understanding the physical and chemical behavior of plutonium compounds is essential for advanced nuclear fuels, stewardship of the Nation's nuclear stockpile, powering interplanetary exploration, and long-term storage of nuclear waste. From the inception of NMR over 50 years ago, scientists searched for the NMR signature of plutonium-239, which had remained the only element with a spin ½ nucleus not detected by NMR. The key to the discovery of the plutonium-239 resonance was the use of a high purity solid sample of plutonium dioxide at very low temperatures.

Materials Resist Radiation Damage. For nuclear reactors, radiation-resistant materials are essential. In an assessment of the interaction between material structure and radiation-induced defects, a sweet spot has been discovered where the damage is repaired as fast as it is created. Exposure to radiation creates defects in materials that can build up over time and lead to failure. Nanoporous materials with high surface areas can allow the defects to escape to the surface and reduce damage accumulation. Recent research has correlated the optimal surface to volume ratio for nanoporous materials enabling full recovery from damage as the defects are created for a given irradiation dose rate.

New Insights into Combustion Chemistry. New probes of gas-phase chemistry that combine synchrotrons with mass spectrometry are enabling detailed studies of combustion reactions. Using tunable light to selectively ionize molecules during reactions, scientists detected a transient species called the Criegee intermediate and characterized its reactivity. This elusive molecule—long hypothesized but never before observed—is a key player in combustion chemistry.

Observing the Motions of Atoms within Molecules. Developments in theory and ultrafast lasers are rapidly advancing our ability to observe and control the motions of atoms and electrons within molecules undergoing chemical transformations. Scientists recently reported the first freeze-frame images of atoms in vibrating oxygen and nitrogen molecules by using the molecule's own electrons to report the positions of its atoms. The technique called laser-induced electron diffraction (LIED) uses the oscillating electromagnetic field of an intense laser to pull an electron from a molecule and then hurl that same electron back to diffract from the molecular ion. The re-scattered electron conveys the molecular structure at the moment when it interacts with the atoms in the molecule.

Solar Recycling of Carbon Dioxide. In a direct mimic of natural photosynthesis, pairings of light absorbers and catalysts have been discovered that harvest sunlight and efficiently drive the conversion of carbon dioxide to methanol and other alcohols. Semiconductors, including gallium phosphide and gallium arsenide, act as the light absorbers in these systems, providing high energy electrons to the partner catalyst, which can accept electrons and use them to form alcohols from carbon dioxide. These new systems show great potential for the solar powered conversion of carbon dioxide to fuels and chemicals, offering a way to recycle carbon waste from burning fossil fuels as an alternative to sequestering it.

Fully Coherent Hard X-rays by Self-Seeding of the LCLS Free Electron Laser. With a thin sliver of diamond, scientists at SLAC National Accelerator Laboratory have transformed the Linac Coherent Light Source (LCLS) into an even more precise tool for exploring the nanoworld. In a process called self-seeding, the diamond filters the laser beam to a single x-ray wavelength, which is then amplified in intensity. This represents a significant improvement over the current process, which relies on self-amplified spontaneous emission to generate laser-like x-ray beams at LCLS. The improvements yield laser pulses with higher intensity in a much narrower band of x-ray wavelengths. This advance promises to extend that revolution to the x-ray regime, providing extraordinary probes of complex material behavior and control of matter through manipulation of core level electrons with fully coherent x-ray pulses.

BES Synchrotron Facility Assists Industry in Developing Revolutionary Solar Energy Technology. Research on solar photovoltaic materials at the Advanced Photon Source

(APS) at Argonne National Laboratory resulted in fundamental information to develop the first solar shingles, which could reinvent the roofs of our houses. Industry researchers conducted a series of studies at APS to investigate the detailed relationship among process, structure, and property of materials that are suitable for solar energy conversion. These studies provided crucial information about the solar active materials to be incorporated as part of the roof shingles.

Milestone	Date
Complete a comprehensive science review of Fuels From Sunlight Energy Innovation Hub. (Chemical Sciences, Geosciences, and Biosciences/Energy Innovation Hubs)	3rd Qtr, FY 2013
Complete a Committee of Visitor's review of the Scientific User Facilities subprogram. (Scientific User Facilities)	3rd Qtr, FY 2013
Award conventional facility construction contract for the Linac Coherent Light Source-II (Construction)	4th Qtr, FY 2014

Program Planning and Management

Factors considered in the planning and management of research activities in BES include:

- new scientific opportunities as determined by recent scientific discoveries and by new ideas submitted in proposals;
- results of external program reviews and international benchmarking activities of entire fields or sub-fields, such as those performed by the National Academy of Sciences; and reports from the federally chartered Basic Energy Sciences Advisory Committee (BESAC);
- in-depth topical workshops, conferences, and principle investigators' meetings of scientists, engineers, and technologists from universities, federal laboratories, and the private sector;
- coordination and planning activities between DOE programs including informal day-to-day contacts among program managers; and interagency coordinating activities;
- evolving mission needs as described by Presidential priorities and DOE and Office of Science (SC) mission statements and strategic plans; and
- Congressional direction.

All research projects supported by BES undergo regular peer review and merit evaluation based on procedures set down in the Title 10 of the Code of Federal Regulations Part 605 for the extramural grant program and in an analogous process for the laboratory programs and scientific user facilities. The BES peer review process evaluates four criteria: scientific and technical merit of the project, appropriateness of the proposed method or approach, competency of the personnel and adequacy of proposed resources, and reasonableness and appropriateness of the proposed budget. The criteria for review may also include other appropriate factors established and announced by BES.

Typically, every BES research project receives external peer review and merit evaluation once every three years to determine whether the research is continued or terminated, consistent with the President's management agenda.[a] Success rates vary, but approximately 10–20% of all BES research projects are terminated over the three-year review cycle. The termination of work that has reached its conclusion, is past its fruition, or has underperformed provides funding to renew or increase support for outstanding performers and initiate promising new research work by scientific investigators with fresh ideas.

Facilities are also reviewed using external, independent review committees operating according to the procedures established for peer review of BES laboratory programs and facilities. Important aspects of the reviews include assessments of the quality of research performed at the facility, the reliability and availability of the facility, user access policies and procedures, user satisfaction, facility staffing levels, R&D activities to advance the facility, management of the facility, long-range goals of the facility, and that all activities are conducted safely and in an environmentally conscientious manner. The outcomes of these reviews help improve operations and develop new models of operation for all BES scientific user facilities.

Facilities that are in design or construction are reviewed according to procedures in DOE Order 413.3B, Program and Project Management for Capital Assets and in the Office of Science's Independent Review Handbook. In general, once a project has entered the construction phase, it is reviewed with external, independent

[a] http://www.whitehouse.gov/sites/default/files/omb/memoranda/2012/m-12-14.pdf

committees approximately twice a year. These Office of Science construction project reviews enlist experts in the technical scope of the facility under construction and focus on its costing, scheduling, and construction management.

Many long-range planning exercises for elements of the BES program are performed under the auspices of BESAC. Of particular note is the BESAC report, *Basic Research Needs to Assure a Secure Energy Future* (2003), which was the foundation for ten follow-on Basic Research Needs workshops (2003–2007) supported by BES in the areas of the hydrogen economy, solar energy utilization, superconductivity, solid-state lighting, advanced nuclear energy systems, combustion of 21st Century transportation fuels, electrical-energy storage, geosciences as it relates to the storage of energy wastes (the long-term storage of both nuclear waste and carbon dioxide), materials under extreme environments, and catalysis for energy applications. Together, these workshops help create a basic research portfolio in the BES program that underpins a national decades-to-century energy strategy.

Building on the series of Basic Research Needs workshops, BESAC wrote five subsequent reports: *Directing Matter and Energy: Five Challenges for Science and the Imagination* (2007) identifies the most important scientific questions and science-driven technical challenges facing BES and describes the importance of these challenges to advances in disciplinary science, to technology development, and to energy and other societal needs. *New Science for a Secure and Sustainable Energy Future* (2008) assimilates the scientific research directions that emerged from the BES Basic Research Needs workshop reports into a comprehensive set of science themes and identifies implementation strategies and tools required to accomplish the science. *Next-Generation Photon Sources for Grand Challenges in Science and Energy* (2008) identifies connections between major new research opportunities and the capabilities of the next generation of light sources. *Science for Energy Technology: Strengthening the Link between Basic Research and Industry* (2010) identifies the scientific priority research directions needed to address the roadblocks and accelerate the innovation of clean energy technologies. *From Quanta to the Continuum: Opportunities for Mesoscale Science* (2012) builds on the decades-long advancements in atomic, molecular, and nano sciences to define the research agenda for mesoscale science—the regime where quantum and classical descriptions of physical phenomena meet.

BESAC also reviews the major elements of the BES program annually using Committees of Visitors (COVs). The first COV review of BES was conducted in 2002, and all elements of the BES program have been reviewed once every three years on a rotating schedule. COVs assess the efficacy and quality of the processes used to solicit, review, recommend, monitor, and document proposal actions; and the quality of the resulting portfolio, specifically the breadth and depth of portfolio elements and the national and international standing of the elements. The next COV will review the Scientific User Facilities subprogram in April 2013, and an additional COV later in 2013 will cover the Energy Frontier Research Centers and Fuels from Sunlight Energy Innovation Hub. All COV reports and BES responses to COV recommendations are available on the BES website at http://science.energy.gov/bes/besac/bes-cov.

<u>Program Goals and Funding</u>

Office of Science performance expectations are focused on four areas:

- Research: Advance fundamental research to understand, predict, and ultimately control matter and energy at the electronic, atomic, and molecular levels to provide foundations for new energy technologies.
- Facility Operations: Sustain a diverse suite of major scientific facilities to provide critical insights to the electronic, atomic, and molecular configurations, often at ultrasmall length and ultrafast time scales.
- Future Facilities: Progress toward completion of the next generation of user facilities that will provide research communities with tools to fabricate, characterize, and develop new materials and chemical processes to advance research across the full range of scientific disciplines and technological research areas.
- Scientific Workforce: Contribute to the effort aimed at ensuring that DOE and the Nation have a sustained pipeline of highly skilled and diverse science, technology, engineering, and mathematics (STEM) workers.

Goal Areas by Subprogram

	Research	Facilities Operations	Future Facilities	Scientific Workforce
Materials Sciences and Engineering	100%	0%	0%	0%
Chemical Sciences, Geosciences, and Biosciences	100%	0%	0%	0%
Scientific User Facilities	7%	84%	9%	0%
Construction	0%	0%	100%	0%
Total, Basic Energy Sciences	44%	45%	11%	0%

Performance Measures

Performance Goal (Measure)	**BES Facility Operations**—Average achieved operation time of BES user facilities as a percentage of total scheduled annual operation time		
Fiscal Year	**2012**	**2013**[a]	**2014**
Target	≥ 90%	≥ 90%	≥ 90%
Result	Met		
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 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		
Fiscal Year	**2012**	**2013**[a]	**2014**
Target	N/A	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
Result	N/A		
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.		

[a] 2013 targets reflect DOE's FY 2013 Budget Request to Congress. FY 2013 target updates can be found in the upcoming FY 2012–2014 Annual Performance Plan and Report.

Explanation of Funding and Program Changes

In FY 2014, BES will support ongoing research at the FY 2012 funding level and the two Energy Innovation Hubs (Fuels from Sunlight and Batteries and Energy Storage). The FY 2014 budget request reflects difficult choices between operating existing facilities, upgrading facilities, and building new user facilities. In FY 2014, BES will support the National Synchrotron Light Source-II (NSLS-II) construction and early operations, Linac Coherent Light Source-II (LCLS-II) construction, and the operations of the five synchrotron light source facilities and the three neutron source facilities at optimal levels. Major item of equipment (MIE) projects for the Advanced Photon Source Upgrade (APS-U) and the NSLS-II Experimental Tools (NEXT) are also continued in FY 2014. The Energy Frontier Research Centers (EFRCs) portfolio will undergo an open re-competition to select new EFRCs and consider renewal applications for existing EFRCs. The FY 2014 EFRC solicitation will feature new scientific initiatives including recently identified opportunities in the computational design of materials and chemical processes and mesoscale science. In FY 2014, responsibility is transferred from the Office of Environmental Management (EM) to BES for long term surveillance and maintenance (LTS&M) for completed EM work scope and for remaining legacy cleanup work scope at BNL and SLAC.

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Materials Sciences and Engineering	345,642	403,928	+58,286
Core research activities continue at the FY 2012 level. A competitive solicitation will be issued for both renewal and new EFRCs. Additional one-time funding is requested to fully forward fund some of the new/renewal EFRC awards. The Batteries and Energy Storage Hub continues at the planned level.			
Chemical Sciences, Geosciences, and Biosciences	308,740	346,993	+38,253
Core research activities and EFRCs continue at the FY 2012 level. A competitive solicitation will be issued for both renewal and new EFRCs. Additional one-time funding is requested to fully forward fund some of the new/renewal EFRC awards. The Fuels from Sunlight Hub continues at the planned level.			
Scientific User Facilities	838,985	990,190	+151,205
Operation of the BES user facilities continue at optimal levels—five light sources, five Nanoscale Science Research Centers, and three neutron sources. Funding will continue the early operations of the NSLS-II in preparation for full operations in FY 2016. Funding for the APS Upgrade and NEXT MIE projects are increased. 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 ($+12,873,000).			
Construction	151,400	121,300	-30,100
Construction of the National Synchrotron Light Source-II (NSLS-II) will be ramped down and funding for the Linac Coherent Light Source-II (LCLS-II) will increase as scheduled.			
Total, Basic Energy Sciences	1,644,767	1,862,411	+217,644

Materials Sciences and Engineering
Funding Profile by Activity

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Scattering and Instrumentation Sciences Research	62,369	—	62,369
Condensed Matter and Materials Physics Research	124,629	—	124,629
Materials Discovery, Design, and Synthesis Research	73,384	—	73,384
Experimental Program to Stimulate Competitive Research (EPSCoR)	8,520	—	8,520
Energy Frontier Research Centers (EFRCs)	57,330	—	97,863
Energy Innovation Hubs—Batteries and Energy Storage	19,410	—	24,237
SBIR/STTR	0	—	12,926
Total, Materials Sciences and Engineering[a]	345,642	—	403,928

[a] SBIR/STTR funding:

- FY 2012 Appropriation: SBIR $9,618,000 and STTR $1,295,000 (transferred out of BES in FY 2012 Current column
- FY 2014 Request: SBIR $11,310,000 and STTR $1,616,000

Overview

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 and their fundamental connections to atomic, molecular, and electronic structures. 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 and enable discovery of new materials with unprecedented functionalities.

The portfolio emphasizes understanding how to direct and control energy flow in materials systems over multiple time and length scales. 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 (e.g., magnetism and superconductors), utilization of nanoscale control, and systems that are metastable or far from equilibrium. Finally, the subprogram exploits 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 basic research spanning the broad range of DOE's science and technology programs in states that have historically received relatively less Federal research funding.

In addition to single-investigator and small-group research, the subprogram supports Energy Frontier Research Centers that were established in FY 2009 and the Batteries and Energy Storage Energy Innovation Hub that began in FY 2013. These research modalities support multi-investigator, multidisciplinary research and focus on forefront energy technology challenges. The Energy Frontier Research Centers 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.

Explanation of Funding Changes

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Scattering and Instrumentation Sciences Research	62,369	62,369	0
Research continues at the FY 2012 level.			
Condensed Matter and Materials Physics Research	124,629	124,629	0
Research continues at the FY 2012 level.			
Materials Discovery, Design, and Synthesis Research	73,384	73,384	0
Research continues at the FY 2012 level.			
Experimental Program to Stimulate Competitive Research (EPSCoR)	8,520	8,520	0
Research continues at the FY 2012 level.			
Energy Frontier Research Centers (EFRCs)	57,330	97,863	+40,533
A competitive solicitation will be issued for both renewal and new EFRCs. Additional one-time funding of $39,863,000 is provided to fully forward fund some of the new/renewal EFRC awards.			
Energy Innovation Hubs—Batteries and Energy Storage	19,410	24,237	+4,827
In FY 2014, Batteries and Energy Storage Hub operations are supported at the planned level.			

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
SBIR/STTR	0	12,926	+12,926
In FY 2012, $9,618,000 and $1,295,000 were transferred to the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs, respectively. SBIR/STTR funding is statutorily set at 3.20% of non-capital funding in FY 2014.			
Total, Materials Sciences and Engineering	345,642	403,928	+58,286

Scattering and Instrumentation Sciences Research

Overview

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 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 at the DOE national laboratories 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 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 neutron optics and techniques with polarized neutrons to probe the properties of materials.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	In FY 2012 research supported scattering research, including continued enhancement of ultrafast research and development of techniques to observe, control and understand material dynamics through the use of electron, optical, neutron, and x-ray techniques and sources.	62,369
FY 2013	The FY 2013 Request proposed $73,721,000 for research that would emphasize timely exploitation of the tremendous enhancements in intensities at DOE's world-leading facilities and new technologies in optics, detectors, and electronics to develop new techniques not previously possible. New research would initiate development of in situ analysis capabilities for materials and chemistry by design and development and application of forefront scattering capabilities, including ultrafast techniques, to address key issues for clean energy. This research would advance the development and utilization of new capabilities with increasing physical, chemical, structural, and temporal precision by the broader clean energy research community, opening new avenues for mesoscale research. Proposed research would emphasize soft and hybrid materials.	—
FY 2014	The research will continue 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 will enable unique insights into the structure and dynamics of new energy materials over relevant time and length scales. Research will advance the development and utilization of new capabilities with increasing physical, chemical, structural, and temporal precision for materials research. Research on soft and hybrid materials will be emphasized.	62,369

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Electron and Scanning Probe Microscopes	24,390	—	24,390
Neutron and X-Ray Scattering	37,979	—	37,979
Total, Scattering and Instrumentation Sciences Research	62,369	—	62,369

Condensed Matter and Materials Physics Research

Overview

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 and liquids 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. The influence of defects in materials and their effects on strength, structure, deformation, and failure over a wide range of length and time scales will enable the design of materials with superior properties and resistance to change under the influence of radiation.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	In FY 2012, combined computational and experimental research supported development of validated theoretical models, which includes additional efforts in predictive theory and modeling, some of which are funded jointly with the Office of Advanced Scientific Computing Research under the SciDAC program. Research supported further advances in our understanding of approaches to control materials properties and to push the frontiers and scientific foundations for new materials such as topological insulators, graphene, and metamaterials. Research continued on materials that underpin the evolution of energy technologies such as superconductors, radiation resistant materials, and photovoltaic, optical, and electronic applications. Research was reduced in granular materials, surface diffusion and reconstruction, liquid crystals, and heat transfer in nanofluidics.	124,629
FY 2013	The FY 2013 Request proposed $148,723,000 to continue to emphasize experimental and theoretical research in newly discovered systems that exhibit correlation effects including graphene and topological insulators. Research on ultra-cold atom clusters would be supported to provide new insights into the evolution of condensed matter behavior.	—

Fiscal Year	Activity	Funding (dollars in thousands)
	New research in materials and chemistry by design would emphasize development of validated software that could be used by the broader community, including the development of new theoretical tools that relate directly to clean energy technologies. Additional research would explore mesoscale phenomena and enhance use-inspired clean energy research relevant to solar energy utilization, mechanical properties and radiation effects, and correlated electron behavior in materials, such as superconductivity and magnetism that are important to a number of energy technologies. The new research would focus on advancing our fundamental understanding of defects in materials, which was needed to extend lifetimes and enhance performance of materials used in energy generation and use. Proposed research would continue to support fundamental insights to the understanding of structure-property relationships, including the influence of reduced dimensionality and defects on physical, optical, and electrical properties, and controlling material functionality in response to multiple external stimuli such as temperature, pressure, magnetic and electric fields, and radiation.	
FY 2014	Research will continue 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 will focus on advancing our 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 will support 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 will be 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	124,629

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Experimental Condensed Matter Physics	43,441	—	43,441
Theoretical Condensed Matter Physics	35,544	—	35,544
Mechanical Behavior and Radiation Effects	20,226	—	20,226
Physical Behavior of Materials	25,418	—	25,418
Total, Condensed Matter and Materials Physics Research	124,629	—	124,629

Materials Discovery, Design, and Synthesis Research

Overview

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 biomimetic and bioinspired 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 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.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	In FY 2012, research was focused on enhancing the scientific foundations for understanding the fundamentals of synthesis, fabrication and processing of materials with physical, chemical, and biomimetic approaches. Additional emphasis areas included integration of theory, computation, and experiment to enhance capabilities for materials discovery. Research was reduced in activities on ion beam assisted growth techniques, artificial enzymes, and synthesis of individual nanowires, particles, etc.	73,384
FY 2013	The FY 2013 Request proposed $84,585,000 for research to continue to emphasize integration of experimental and theory activities to accelerate progress in understanding synthesis and discovery of new materials, bio-inspired synthesis toward more efficient processes that would scale to larger quantities and result in resilient materials, porous materials modeled after biological membranes, and related features.	—

Fiscal Year	Activity	Funding (dollars in thousands)
	New directions in use-inspired clean energy research would have considered opportunities related to mesoscale science, including self-healing materials to extend the lifetimes of materials in solar devices and for solar energy conversion. New research underpinning carbon capture would take advantage of novel chemistries and approaches for gas storage and release, including innovative biomolecular materials research. Research would focus on obtaining a deeper understanding of the role of interfaces in the processes underpinning energy storage and catalytic technologies. Experimental research would support materials and chemistry by design, including predictive design of materials synthesis through development of validated software for physical and chemical synthesis and processing techniques. Proposed research would continue to emphasize the development of new strategies and methods to direct and control the assembly of materials structures across a range of length scales.	
FY 2014	Research will continue on the development of guiding principles for the predictive design and synthesis of materials across multiple length scales—from atomic and molecular to nano to meso and ultimately to bulk. Predictive design of materials synthesis will be coupled to experimental research on biology-inspired, physical, and chemical synthesis and processing techniques. This will be made possible by more 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 will take advantage of novel chemistries and approaches for gas storage and release, including innovative biomolecular materials research.	73,384

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Materials Chemistry and Biomolecular Materials	53,382	—	53,382
Synthesis and Processing Science	20,002	—	20,002
Total, Materials Discovery, Design, and Synthesis Research	73,384	—	73,384

Experimental Program to Stimulate Competitive Research (EPSCoR)

Overview

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. The EPSCoR states/territories are listed below. EPSCoR helps these states develop their infrastructure and research capabilities so that they can successfully compete for research funding. The research supported by EPSCoR includes 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, 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.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Research continued to support basic research related to DOE mission areas with emphasis on science underpinning the DOE energy technology programs broadly.	8,520
FY 2013	The FY 2013 Request proposed $8,520,000 for research efforts that would continue to span science areas in support of the DOE mission, with emphasis on science underpinning the DOE energy technology programs broadly. EPSCoR implementation grants would be enhanced.	—
FY 2014	Efforts will continue to span science in support of the DOE mission, with continued emphasis on science that underpins DOE energy technology programs. Collaborative efforts with DOE laboratories and user facilities will continue to be supported and funding for implementation grants will be enhanced.	8,520

EPSCoR Distribution of Funds by State

(dollars in thousands

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Alabama	0	—	0
Alaska	0	—	0
Arkansas	0	—	0
Delaware	979	—	150
Guam	0	—	0

	(dollars in thousands		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Hawaii	0	—	0
Idaho	0	—	0
Iowa[b]	0	—	0
Kansas	150	—	0
Kentucky	590	—	0
Louisiana	0	—	0
Maine	600	—	0
Mississippi	0	—	0
Missouri	0	—	0
Montana	125	—	0
Nebraska	0	—	0
Nevada	0	—	0
New Hampshire	700	—	0
New Mexico	150	—	150
North Dakota	150	—	150
Oklahoma	0	—	0
Puerto Rico	1,511	—	0
Rhode Island	1,932	—	150
South Carolina	0	—	0
South Dakota	0	—	0
Tennessee[b]	1,333	—	553
U.S. Virgin Islands	0	—	0
Utah[b]	0	—	0
Vermont	0	—	0
West Virginia	300	—	0
Wyoming	0	—	0
Technical Support	0	—	75
Other[a]	0	—	7,292
Total, EPSCoR	8,520	—	8,520

[a] Uncommitted funds in FY 2013 and FY 2014 will be competed among the EPSCoR states.

[b] Iowa, Tennessee, and Utah will lose EPSCoR eligibility in FY 2013; existing awards will continue to their end date.

Energy Frontier Research Centers

Overview

The Energy Frontier Research Centers (EFRCs), initiated in FY 2009, 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. In the first award cycle, there were 46 EFRC awards, 16 funded for a full 5-year award term through the American Recovery and Reinvestment Act (ARRA) of 2009 and 30 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.

BES's active management of the EFRCs is an important feature of the program. A variety of methods are used to regularly assess the ongoing 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 has also conducted two in-person reviews by outside experts. Each EFRC underwent a review of its management structure and approach in the first year of operation (2010) and a midterm assessment that focused on each EFRC's scientific program and progress compared to its 5-year research goals (2012). In addition, BES organized a meeting of EFRC scientific staff in the second year, 2011, to facilitate collaboration and information exchanges; a second meeting is planned for the fourth year, 2013. These meetings and Directors' meetings provide opportunities for communication between the EFRCs and DOE programs. Representatives from the DOE technology programs are invited to these events to discuss the latest advances in scientific understanding from EFRC research. The technology offices also help to ensure, through presentations and individual interactions, that the EFRCs are cognizant of the current problems facing different energy sectors.

The mid-term assessment in FY 2012 provided a comprehensive peer review of the entire EFRC portfolio. The process found that the EFRCs are accelerating energy science by bringing together world-class scientists from different disciplines to tackle challenging problems in new ways; providing an environment that encourages high-risk, high-reward research that would not be done otherwise; integrating synthesis, characterization, theory, and computation to accelerate the rate of scientific progress; developing new, innovative experimental and theoretical tools that illuminate fundamental processes in unprecedented detail; and creating an enthusiastic, inter-disciplinary community of energy-focused scientists that will ensure a future workforce for the United States in these critical fields. The EFRCs have demonstrated significant scientific productivity as shown by publications, invention disclosures, patents, and transfer of research results to companies and applied research efforts. As of January 2013, the EFRCs had authored over 3,400 peer-reviewed publications. Although the focus of the EFRCs is fundamental energy-use-inspired science, many centers have reported that their results are already impacting both technology research and industry. There are over 200 patents/applications, with at least 30 associated licenses, plus more than 60 unpatented invention disclosures. Centers have reported that 60 companies are using the results of EFRC research, including small start-ups and major corporations. Many of the EFRCs are interfacing with DOE's technology and small business programs to accelerate the transition of promising scientific results to commercial applications.

The mid-term assessment found the EFRC program to be strong and to have a unique role in advancing fundamental science relevant to energy technologies. The centers provide an important bridge between basic research and energy technologies and complement other research activities funded by DOE. The remaining funding of the first five-year award period will be distributed in FY 2013. For FY 2014, an open re-competition is planned to select new EFRCs and consider renewal applications for existing EFRCs. As in the original competition, the FY 2014 EFRC solicitation will target basic research across the broad range of science needed to provide a foundation of transformative energy technologies. The solicitation will incorporate new areas of energy-relevant research that have been identified by recent BES and BESAC workshop reports, including: *Computational Materials Science and Chemistry: Accelerating Discovery and Innovation Through Simulation-Based Engineering and Science; From Quanta to the Continuum: Opportunities for Mesoscale Science; Basic Research Needs for Carbon Capture: Beyond 2020;* and *Science for Energy Technology: Strengthening the Link Between Basic Research and Industry*. The FY 2014 EFRC solicitation will feature new scientific initiatives including research to advance the rate of materials and chemical discovery and a "molecules to mesoscale" approach to directed-assembly of mesoscale structures with unique functionality, emulating biological systems in the development of man-made energy materials and systems and enabling bottom-up design of materials with nanoscale functional units to produce next generation technological innovation. Renewal and new applications will be assessed via rigorous peer review; awards will be based on scientific and technical merit and the achievement of a balanced EFRC portfolio for use-inspired basic energy research.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	The EFRCs completed their third year of operation in late FY 2012. In January–April 2012, a panel-based peer-review assessed the scientific progress and productivity of each EFRC. At the conclusion of the assessment, BES determined that all centers should continue to the end of the current award period since each is meeting or exceeding the expected progress toward their research goals and is likely to have substantial future impact on their scientific disciplines.	57,330
FY 2013	The FY 2013 Request proposed $68,000,000 for research that would incorporate modifications to research activities and directions resulting from the FY 2012 peer review. Additional funding would accelerate the transition of novel scientific discoveries from the EFRCs into innovative, prototype clean energy technologies and to improve coordination between fundamental research conducted in the EFRCs and applied research and engineering development supported by EERE.	—
FY 2014	A single funding opportunity announcement (FOA) will be issued for both renewal and new EFRCs for five-year awards beginning in FY2014. The EFRC FOA will encourage 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, will have 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. Awardees receiving renewal funding will also be assessed on progress during the first five-year award. One-time funding in the amount of $39,863,000 is provided to fully forward fund some of the new/renewal EFRC awards.	97,863

Energy Innovation Hubs—Batteries and Energy Storage

Overview

Energy Innovation Hubs are composed of a large, multidisciplinary team of investigators whose research integrates basic to applied research and focuses on a single critical national energy need. Hubs include a central location for the research and extensive cross-team interactions to accelerate the research and technology development. They are funded as five-year, potentially renewable projects.

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 electrical 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 capacities are needed to expand the range of electric vehicles' from a single charge while simultaneously decreasing the 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, cycle life limitations, low abuse tolerance, high cost, and decreased performance at high or low temperatures. The Batteries and Energy Storage Hub focuses on understanding the fundamental performance limitations for electrochemical energy storage to launch the next generation of energy storage technologies.

The Batteries and Energy Storage Hub will accelerate the development of energy storage solutions that are well beyond current capabilities and approach theoretical limits. This development will be enabled by cross-disciplinary R&D focused on the barriers to transforming electrochemical energy storage, including the exploration of new materials, architectures, chemistries, systems, and novel approaches for transportation and utility-scale storage. Outside of the Hub, battery research is typically focused on one particular problem or research challenge and thus lacks the resources and the diverse breadth of talent to consider holistic solutions. The Hub will provide this critical mass directed on research to overcome the current technical limits for electrochemical energy storage to the point that the risk level will be low enough for industry to further develop the innovations discovered by the Hub and deploy these new technologies into the marketplace.

The Hub's goal is to deliver revolutionary research that will result in new technologies and approaches, rather than focusing on a single technology or incremental improvements to current technologies. While advancing the current understanding and underpinning science for energy storage, the Hub will include the development of working bench-top prototype devices that demonstrate radically new approaches for electrochemical storage that are scalable. These should have the potential to be produced at low manufacturing cost from earth-abundant materials and possess greatly improved properties compared to present commercially available energy storage technologies.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	The Hub applications were assessed through peer-review. The Hub proposal and management plan provided specific performance objectives and milestones that were confirmed through the award process and early stages of Hub operations. These provided the baseline for future assessments of Hub progress.	19,410

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2013	The FY 2013 Request proposed $24,237,000 for Hub research that would follow the plan established in the proposal. A management peer review would evaluate the Hub's progress in fulfilling the research plan. The first scientific publications would appear, advisory groups would be operational (including industrial input), and a communications network would be established by the Hub.	—
FY 2014	Hub research on electrochemical energy storage will continue 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 will be informed by the management review. A full peer review of the technical progress of the Hub research will occur in the September-October time frame.	24,237

Chemical Sciences, Geosciences, and Biosciences
Funding Profile by Activity

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Fundamental Interactions Research	75,510	—	76,047
Chemical Transformations Research	94,331	—	94,553
Photochemistry and Biochemistry Research	69,114	—	69,605
Energy Frontier Research Centers (EFRCs)	42,670	—	70,866
Energy Innovation Hubs—Fuels From Sunlight	24,263	—	24,237
GPP	2,852	—	600
SBIR/STTR	0	—	11,085
Total, Chemical Sciences, Geosciences, and Biosciences[a]	308,740	—	346,993

[a] SBIR/STTR funding:

- FY 2012 Appropriation: SBIR $8,286,000 and STTR $1,115,000 (transferred out of BES in FY 2012 Current column
- FY 2014 Request: SBIR $9,699,000 and STTR $1,386,000

Overview

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 Energy Frontier Research Centers that were established in FY 2009 and the Fuels from Sunlight Energy Innovation Hub that was awarded in FY 2010. 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.

Explanation of Funding Changes

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Fundamental Interactions Research	75,510	76,047	+537
Research continues at approximately the FY 2012 level, which includes additional efforts in predictive theory and modeling, some of which are funded jointly with the Office of Advanced Scientific Computing Research under the SciDAC program.			
Chemical Transformations Research	94,331	94,553	+222
Research continues at approximately the FY 2012 level.			
Photochemistry and Biochemistry Research	69,114	69,605	+491
Research continues at approximately the FY 2012 level			
Energy Frontier Research Centers	42,670	70,866	+28,196
EFRCs continue at the FY 2012 request level. A competitive solicitation will be issued for both renewal and new EFRCs. Additional one-time funding of $28,866,000 is provided to fully forward fund some of the new EFRC awards.			

	(dollars in thousands)		
	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Energy Innovation Hubs—Fuels From Sunlight	24,263	24,237	-26
In FY 2014, the Fuels From Sunlight Hub operations are supported at the planned annual level.			
GPP	2,852	600	-2,252
Funds are provided for facility improvements at Ames Laboratory.			
SBIR/STTR	0	11,085	+11,085
In FY 2012, $8,286,000 and $1,115,000 were transferred to the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs, respectively. SBIR/STTR funding is statutorily set at 3.20% of non-capital funding in FY 2014.			
Total, Chemical Sciences, Geosciences, and Biosciences	308,740	346,993	+38,253

Fundamental Interactions Research

Overview

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 principle 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 (CRF), a multi-investigator research laboratory at Sandia National Laboratory in Livermore, CA, for the study of combustion science.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Core research activities continued with emphasis on the development and application of new ultrafast x-ray and optical probes of matter. New research emphasized the chemistry associated with stochastic combustion processes and the fundamental science of liquid fuel injection, both of which are required to further enable the predictive simulation of internal combustion engines. Additional new research emphasized advancing predictive theory and modeling, some of which are funded jointly with the Office of Advanced Scientific Computing Research under the SciDAC program. Topical focus areas included advanced computational chemistry for catalysis and improved treatment of electronic states for advancing predictive capability for photovoltaic and photocatalytic materials.	75,510

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2013	The FY 2013 Request proposed $71,562,000 for AMO sciences research that would emphasize the development and application of new ultrafast x-ray and optical probes of matter, including experiments at the Linac Coherent Light Source and BES synchrotron light sources and theoretical and computational methods for the interpretation of ultrafast measurements. Chemical physics research would have been emphasized development of new theoretical and simulation techniques relevant to a wide variety of potential applications. As part of the effort on materials and chemistry by design, increases would provide for the use of optical fields to control and design quantum mechanical systems and for new computational chemistry approaches to electronically excited states in molecules and extended mesoscale systems, which are critically important in solar energy conversion. As part of science in supporting a clean energy agenda, an increase would be provided for advanced combustion research to accelerate the predictive simulation of internal combustion engines.	—
FY 2014	AMO sciences research will continue 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. Emphasis will be 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. New computational chemistry will stress improved methods for electronically excited states in molecules and extended mesoscale systems, which are critically important to the design of energy conversion processes and materials. Chemical physics research will emphasize development of new theoretical and simulation techniques relevant to a wide variety of potential applications. Work will continue on advanced combustion research to accelerate the predictive simulation of highly efficient and clean internal combustion engines.	76,047

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Chemical Physics Research	54,453	—	54,840
Atomic, Molecular, and Optical Science	21,057	—	21,207
Total, Fundamental Interactions Research	75,510	—	76,047

Chemical Transformations Research

Overview

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.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Core research activities continued and included emphasis on the combination of computational design, directed synthesis, and molecular-scale characterization to create and optimize novel catalysts. Other areas of research emphasis included fluid flow in nanoscale membranes, fundamental actinide chemistry, and the translation of interfacial chemistry into the geosciences arena in order to improve our understanding of subsurface geochemistry.	94,331
FY 2013	The FY 2013 Request proposed $110,875,000. As part of the materials and chemistry by design effort, an increase would be provided for the development of computational methods and software tools for the simulation of photo-catalytic, fuel-forming reactions and for complementary efforts in synthesis and characterization of new catalytic materials that are designed at the nanoscale to function on the mesoscale. As part of science in supporting a clean energy agenda, increases would provide for 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. Additional clean energy increases were proposed for actinide research in support of advanced nuclear energy systems, with emphasis on complex separation chemistry addressing the multiplicity of chemical forms and oxidation states in actinides for nuclear fuels and waste forms, and for advanced catalytic approaches to the conversion of biomass to fuels and other chemical products.	—

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2014	Research will emphasize 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 will be 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, will be explored. Actinide research in support of advanced nuclear energy systems will continue, with emphasis on complex separation chemistry addressing the multiplicity of chemical forms and oxidation states in actinides for nuclear fuels and waste forms.	94,553

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Catalysis Science	46,110	—	46,438
Separations and Analysis	12,664	—	12,754
Heavy Element Chemistry	15,042	—	14,700
Geosciences Research	20,515	—	20,661
Total, Chemical Transformations Research	94,331	—	94,553

Photochemistry and Biochemistry Research

Overview

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.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Ongoing research activities included efforts to define molecular-level structure-function relationships of the natural photosynthetic apparatus and apply that knowledge to synthetic solar fuel systems, including the design of ligands that further increase the reactivity of metal-based catalytic complexes. Efforts continued to understand the biophysical and biochemical parameters that make the plant cell wall recalcitrant to catalytic conversion into fuels and other value-added products.	69,114
FY 2013	The FY 2013 Request proposed $77,822,000. As part of the materials and chemistry by design effort, an increase would provide for the development of computational methods and software tools for the simulation of light harvesting and conversion of solar energy into electricity and fuels (in coordination with the *Chemical Transformations* activity). As part of science in supporting a clean energy agenda, increases provide for 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. 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).	—

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2014	The development of computational methods for the simulation of light harvesting and conversion of solar energy into electricity and fuels will be 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, will be 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).	69,605

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Photosynthetic Systems	16,920	—	17,040
Physical Biosciences	16,274	—	16,390
Solar Photochemistry	35,920	—	36,175
Total, Photochemistry and Biochemistry Research	69,114	—	69,605

Energy Frontier Research Centers

Overview

The Energy Frontier Research Centers (EFRCs), initiated in FY 2009, 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. There were 46 EFRC awards, 16 funded for a full 5-year award term through the American Recovery and Reinvestment Act (ARRA) of 2009 and 30 funded on a continuing basis through annual appropriations through this subprogram and the Materials Science 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.

BES's active management of the EFRCs is an important feature of the program. A variety of methods are used to regularly assess the ongoing 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 has also conducted two in-person reviews by outside experts. Each EFRC underwent a review of its management structure and approach in the first year of operation (2010) and a midterm assessment that focused on each EFRC's scientific program and progress compared to its 5-year research goals (2012). In addition, BES organized a meeting of EFRC scientific staff in the second year, 2011, to facilitate collaboration and information exchanges; a second meeting is planned for the fourth year, 2013. These meetings and Directors' meetings provide opportunities for communication between the EFRCs and DOE programs. Representatives from the DOE technology programs are invited to these events to discuss the latest advances in scientific understanding from EFRC research. The technology offices also help to ensure, through presentations and individual interactions, that the EFRCs are cognizant of the current problems facing different energy sectors. The mid-term assessment in FY 2012 provided a comprehensive peer review of the entire EFRC portfolio. The process found that the EFRCs are accelerating energy science by bringing together world-class scientists from different disciplines to tackle challenging problems in new ways; providing an environment that encourages high-risk, high-reward research that would not be done otherwise; integrating synthesis, characterization, theory, and computation to accelerate the rate of scientific progress; developing new, innovative experimental and theoretical tools that illuminate fundamental processes in unprecedented detail; and creating an enthusiastic, inter-disciplinary community of energy-focused scientists that will ensure a future workforce for the United States in these critical fields. The EFRCs have demonstrated significant scientific progress as shown by publications, invention disclosures, patents, and transfer of research results to companies and applied research efforts. As of January 2013, the EFRCs had authored over 3,400 peer-reviewed publications. Although the focus of the EFRCs is fundamental energy-use-inspired science, their results have impacted technology research and industry. There are over 200 patents/applications, with at least 30 associated licenses, plus more than 60 unpatented invention disclosures. Over 60 companies are using the results of EFRC research, including small start-ups and major corporations. Many of the EFRCs are interfacing with DOE's technology and small business programs to advance the transition of promising scientific results to commercial applications.

The mid-term assessment confirmed that the EFRCs are a productive research modality. The centers provide an important bridge between basic research and energy technologies and complement other research activities funded by DOE. The final funding for the first five-year award period will be distributed in FY 2013. For FY 2014, an open re-competition is planned to select new EFRCs and consider renewal applications for existing EFRCs. As in the original competition, the FY 2014 EFRC solicitation will target basic research across the broad range of science needed to provide a foundation of transformative energy technologies. The solicitation will incorporate new areas of energy-relevant research that have been identified by recent BES and BESAC workshop reports, including: *Computational Materials Science and Chemistry: Accelerating Discovery and Innovation Through Simulation-Based Engineering and Science; From Quanta to the Continuum: Opportunities for Mesoscale Science; Basic Research Needs for Carbon Capture: Beyond 2020;* and *Science for Energy Technology: Strengthening the Link Between Basic Research and Industry*. The FY 2014 EFRC solicitation will feature new scientific initiatives including research to advance the rate of materials and chemical discovery and a "molecules to mesoscale" approach to directed-assembly of mesoscale structures with unique functionality, emulating biological systems in the development of man-made energy materials and systems and enabling bottom-up design of materials with nanoscale functional units to produce next generation technological innovation. Renewal and new applications will be assessed via rigorous peer review with awards will be based on scientific and technical merit and the achievement of a balanced EFRC portfolio for use-inspired basic energy research.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	The EFRCs completed their third year of operation in late FY 2012. To date, the 46 EFRCs have produced more than 2,000 peer reviewed publications and more than 90 invention disclosures, patent applications, and patents. About 10 start-up companies are commercializing EFRC discoveries. In January–April 2012, a panel-based peer-review assessed the scientific progress of each EFRC. These reviews identified numerous examples of extraordinary performance as well as specific opportunities to enhance scientific impact. Reviewers consistently praised the EFRC approach to delivering scientific advances and innovations.	42,670
FY 2013	The FY 2013 Request proposed $52,000,000 for research that would incorporate modifications to research activities and directions resulting from the FY 2012 peer review. Additional funding would accelerate the transition of novel scientific discoveries from the EFRCs into innovative, prototype clean energy technologies and to improve coordination between fundamental research conducted in the EFRCs and applied research and engineering development supported by EERE.	—
FY 2014	A single funding opportunity announcement (FOA) will be issued for both renewal and new EFRCs for five-year awards beginning in FY2014. The EFRC FOA will encourage 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, will have the opportunity to compete for a second five-year performance period. Renewal awards will be based on rigorous peer review that includes assessment of progress during the first five-year award and evaluation of the research proposed for the subsequent five years. New EFRC awards will be based on rigorous peer review of research proposed for an initial five-year award period. One-time funding in the amount of $28,866,000 is provided to fully forward fund some of the new/renewal EFRC awards.	70,866

Energy Innovation Hubs—Fuels from Sunlight

Overview

Established in September 2010, the Fuels from Sunlight Hub is designed as a potentially renewable five-year project to bring together a multi-disciplinary, multi-investigator, multi-institutional team to create transformative advances in the development of artificial photosynthetic systems that convert sunlight, water, and carbon dioxide into a range of commercially useful fuels. This Hub, the Joint Center for Artificial Photosynthesis (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 that seek to integrate decades of community effort in light harvesting and conversion, homogeneous and heterogeneous catalysis, interfacing, membrane and mesoscale assembly, and computational modeling and simulation, with more current research efforts using powerful new tools to examine, understand, and manipulate matter at the nanoscale. By studying the science of scale-up and benchmarking both components (catalysts) and systems (device prototypes), JCAP seeks to accelerate the transition from laboratory discovery to industrial use.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	In FY 2012, JCAP has successfully completed its proposed milestones for the second project year. The renovations of the JCAP laboratory at Caltech were completed on schedule and on budget; the laboratory is fully equipped and is occupied for use by JCAP staff from Caltech and the University of California partners. Staffing is on pace to achieve the target of 150–180 scientists and engineers, with approximately 60 now participating in JCAP activities on a daily basis. Significant advances have been made on accelerating discovery of new components, including the establishment of innovative high-throughput capabilities for screening an unprecedented number of light absorbers and catalysts. Excellent progress has been made in the design and synthesis of membranes that provide ionic pathways, good optical properties, and are effective at separating product fuels. JCAP has continued its efforts to integrate the solar fuels community through symposia and workshops, tool development, and principal investigators' meetings. In April 2012, an external peer review assessed the scientific and technical progress of JCAP. This review indicated JCAP performance to be on track and provided useful feedback for improving JCAP productivity through enhanced synergy among research projects. The JCAP award was initiated in late September 2010 and JCAP project years correspond approximately to the subsequent fiscal year, e.g., JCAP project year one (supported with FY 2010 funding) occurred in FY 2011 and JCAP project year two occurred in FY 2012 (supported with FY 2011 funding).	24,263
FY 2013	The FY 2013 Request proposed $24,237,000 for JCAP. Performance milestones emphasized the integration and benchmarking of components as part of a complete system. Areas of increased emphasis include extensive use of SC leadership class computational facilities and synchrotron light sources for materials design and characterization, the development of scientific scale-up procedures for nanoscale device components, and the establishment of a number of prototype solar-to-fuels devices for component (light harvesters, catalysts, membranes, etc.) testing and optimization.	—

Fiscal Year	Activity	Funding (dollars in thousands)
	The FY 2013 Budget proposed extensive collaboration between the external scientific and technical communities and JCAP in order to test and redesign light absorbers and catalysts. The proposed efforts would significantly increase interactions with and/or licensing to industry in order to develop targeted direct solar fuels technologies.	
FY 2014	In FY 2014, JCAP performance milestones emphasize prototype development. Areas of increased emphasis will include: analysis of components, materials and chemical inputs, and hardware designs with respect to manufacturability, life-cycle analysis, and reuse to ensure the scalability of the first-generation, solar fuels generation system. Additional efforts will be 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.	24,237

General Plant Projects (GPP)

Overview

GPP funding is provided for minor new construction, for other capital alterations and additions, and for improvements to land, buildings, and utility systems principally at the Ames Laboratory and the Combustion Research Facility (CRF) at Sandia National Laboratories. 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.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Funding will support minor facility improvements at Ames Laboratory, the Ames Sensitive Instrument Facility at Ames Laboratory, and the seismic retrofit for the CRF office building at Sandia National Laboratories.	2,852
FY 2013	The FY 2013 Request proposed $2,315,000 to support minor infrastructure improvements and upgrades at Ames Laboratory.	—
FY 2014	Funding will support minor facility improvements at Ames Laboratory.	600

Scientific User Facilities
Funding Profile by Activity

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Synchrotron Radiation Light Sources	381,012	—	464,000
High-Flux Neutron Sources	249,000	—	261,490
Nanoscale Science Research Centers	102,781	—	106,500
Other Project Costs	7,700	—	28,100
Major Items of Equipment	73,500	—	64,200
Research	24,992	—	36,966
SBIR/STTR	0	—	28,934
Total, Scientific User Facilities[a]	838,985	—	990,190

[a] SBIR/STTR funding:

- FY 2012 Appropriation: SBIR $20,282,000 and STTR $2,730,000 (transferred out of BES in FY 2012 Current column)
- FY 2014 Request: SBIR $25,317,000 and STTR $3,617,000

Overview

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 of 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 measure 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 atoms being investigated. SC's large-scale user facilities consist of a complementary set of intense x-ray sources, neutron scattering centers, electron beam characterization capabilities, 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 14,000 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.

Explanation of Funding Changes

The overarching strategy for this subprogram focuses on maintaining U.S. scientific leadership by ensuring that the BES-supported scientific tools and instrumentation stay at the technological forefront and continue to charter new paths for revolutionary discoveries. The U.S. is a global leader in the photon sciences as reflected in the stellar performance and impacts of the suite of five synchrotron radiation light source facilities supported by BES. These facilities are critical to maintaining the Nation's base of scientific innovations and require sustained support.

The BES program leads the world in the conception, design, construction, and operation of large-scale synchrotron radiation light sources and neutron scattering facilities. The FY 2014 budget request reflects difficult, considered choices between the operations of existing facilities, upgrading facilities, and building new user facilities that will supersede today's facilities by providing totally new capabilities that are not in existence today. Although it will be several years—and perhaps more than a decade—before major new facilities can contribute directly to the national research effort, their design and construction are essential for the effective evolution of advanced science and technology in the United States. The operation of existing facilities and the design of new facilities complement one another in function, time scale, and required resources. Optimally operating existing facilities is essential for maintaining a healthy pace of scientific discoveries.

The FY 2014 budget request fulfills stewardship responsibilities to ensure continued operations of BES user facilities and high-priority upgrades in their capabilities. FY 2014 will continue the early operations of the National Synchrotron Light Source-II (NSLS-II) in preparation for full operations in FY 2015, and funding will be provided to continue the NSLS-II Experimental Tools (NEXT) project, which will add additional best-in-class beamlines to NSLS-II. The budget request also supports the upgrade of the Advanced Photon Source.

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Synchrotron Radiation Light Sources	381,012	464,000	+82,988
Increases in funding allow for continued operations of facilities at an optimal level. The National Synchrotron Light Source-II (NSLS-II) at Brookhaven National Laboratory continues its second year of early operations in FY 2014.			
High-Flux Neutron Sources	249,000	261,490	+12,490
Funding allows for continued operation of HFIR and SNS at an optimal level.			
Nanoscale Science Research Centers (NSRCs)	102,781	106,500	+3,719
Funding allow for continued support of users at the NSRCs at optimal levels.			
Other Project Costs	7,700	28,100	+20,400
Increased funding is requested in FY 2014 for other project costs associated with the NSLS-II at BNL and with the LCLS-II at SLAC according to the project plan.			

	(dollars in thousands)		
	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Major Items of Equipment	73,500	64,200	-9,300
Funding will be provided to support the Advanced Photon Source Upgrade (APS-U) at Argonne National Laboratory and NEXT MIE at NSLS-II at Brookhaven National Laboratory. LCLS-II is included as a construction project in the FY 2014 request.			
Research	24,992	36,966	+11,974
Funding to support accelerator and detector research and the electron beam microcharacterization centers continues at the FY 2012 level. In FY 2014, responsibility is transferred from EM to BES for long term surveillance and maintenance (LTS&M) and for remaining legacy clean work scope at BNL and SLAC.			
SBIR/STTR	0	28,934	+28,934
In FY 2012, $20,282,000 and $2,730,000 were transferred to the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs, respectively. SBIR/STTR funding is set at 3.20% of non-capital funding FY 2014.			
Total, Scientific User Facilities	838,985	990,190	+151,205

Synchrotron Radiation Light Sources

Overview

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 early 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 synchrotron radiation 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), National Synchrotron Light Source (NSLS) at Brookhaven National Laboratory (BNL), and Stanford Synchrotron Radiation Lightsource (SSRL) at SLAC. 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.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Funds were provided to support the continued operations of the BES synchrotron radiation light sources. The FY 2012 funding was below the optimal level and will likely impact machine maintenance and user support.	381,012
FY 2013	The FY 2013 Request proposed $438,800,000 for the National Synchrotron Light Source-II (NSLS-II) early operations in addition to supporting the operations of the five BES synchrotron radiation light source facilities at near optimal levels. New collaborative efforts with EERE would be initiated at BES light sources to accelerate the transition of novel scientific discoveries into innovative, prototype clean energy technologies. Funding requested would support procurement of instrumentation dedicated to clean energy research.	—

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2014	In FY 2014, funding is requested to continue the early operations of the NSLS-II in addition to supporting the operations of the five BES synchrotron radiation light source facilities at optimal levels	464,000

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Advanced Light Source, LBNL	63,200	—	63,700
Advanced Photon Source, ANL	123,265	—	130,000
National Synchrotron Light Source, BNL	36,000	—	35,000
National Synchrotron Light Source-II, BNL	0	—	69,000
Stanford Synchrotron Radiation Lightsource, SLAC	34,647	—	38,500
Linac Coherent Light Source, SLAC	123,900	—	127,800
Total, Synchrotron Radiation Light Sources	381,012	—	464,000

High-Flux Neutron Sources

Overview

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 unthought-of capabilities. 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 an energy similar to atoms in materials allowing 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, so that different chemical sites can be distinguished in isotope substitution experiments, for example in organic and biological materials;
- they have a suitable magnetic moment for probing magnetism in condensed matter; 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 to provide state-of-the-art facilities for neutron scattering, materials irradiation, and neutron activation analysis and is the world's leading source of elements heavier than plutonium for medical, industrial and research applications. Two of the triple-axis spectrometers for studying material dynamics and two small-angle scattering spectrometers at the recently installed liquid-hydrogen cold source for measuring structures of condensed matter and biological materials are best in their class world-wide.

Another approach for generating neutron beams is to use an accelerator to generate protons that strike a target made of a heavy metal. 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. SNS is in the process of building out the full suite of 18 beamlines to enable scientists to make neutron measurements of greater sensitivity, higher speed, higher resolution, and in more complex sample environments than ever before.

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 Office of Science (SC) and instruments fabricated by SC and the National Nuclear Security Administration (NNSA) that address both of the needs of the basic research community and the NNSA mission of science-based stockpile stewardship.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Funding was provided to support the operations of the three BES neutron scattering facilities. FY 2012 was the first full year of operation of a new chemical spectrometer for measuring excitations in single crystals, the last instrument built at SNS under the SING-I project.	249,000

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2013	The FY 2013 Request proposed $257,694,000 for near optimal support of user operations. The request supports additional instruments that would have come online at SNS. This would be the first full year of operation of the new chemical spectrometer instrument at SNS.	—
FY 2014	Funding is requested to continue the operations of the HFIR and the SNS at optimal levels. The LANSCE will undergo an upgrade which will reduce the operations of the Lujan Center to 2,000 hours.	261,490

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Spallation Neutron Source, ORNL	180,500	—	190,500
High Flux Isotope Reactor, ORNL	58,000	—	61,175
Lujan Neutron Scattering Center, LANL	10,500	—	9,815
Total, High-Flux Neutron Sources	249,000	—	261,490

Nanoscale Science Research Centers (NSRCs)

Overview

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 centers 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 Argonne National Laboratory (ANL), Center for Functional Nanomaterials at Brookhaven National Laboratory (BNL), Molecular Foundry at Lawrence Berkeley National Laboratory (LBNL), Center for Nanophase Materials Sciences at Oak Ridge National Laboratory (ORNL), and Center for Integrated Nanotechnologies at Sandia National Laboratories and Los Alamos National Laboratory (SNL/LANL). Each center has particular expertise and capabilities in selected theme areas, such as synthesis and characterization of nanomaterials; catalysis; theory, modeling and simulation; electronic materials; nanoscale photonics; soft and biological materials; imaging and spectroscopy; and nanoscale integration. 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.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	In FY 2012, funding was provided to support the user operations and new synthesis and characterization capabilities through techniques development and procurement of new equipment. The goal is to sustain and further develop a robust user program with high scientific and technological impacts at each of the NSRCs.	102,781
FY 2013	The FY 2013 Request proposed $113,500,000 for near optimal operations of the five NSRCs. Continued emphasis would be on developing world leadership in key nanoscale science thrust areas via advancing the state-of-the-art in nanoscale synthesis and characterization tools and in corresponding theory, modeling, and simulation research. New collaborative efforts with EERE would be initiated at the NSRCs to accelerate the transition of novel scientific discoveries into innovative, prototype clean energy technologies. Funding would support procurement of instrumentation dedicated to clean energy research.	—
FY 2014	Funding is requested to continue operations and support of users at the NSRCs at the optimal level. Continued emphasis will be to cultivate and expand the user base from universities, national laboratories, and industry.	106,500

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Center for Nanoscale Materials, ANL	20,500	—	21,300
Center for Functional Nanomaterials, BNL	20,000	—	21,300
Molecular Foundry, LBNL	20,500	—	21,300
Center for Nanophase Materials Sciences, ORNL	20,781	—	21,300
Center for Integrated Nanotechnologies, SNL/LANL	21,000	—	21,300
Total, Nanoscale Science Research Centers (NSRCs)	102,781	—	106,500

Other Project Costs

Overview

The total project cost (TPC) of DOE's construction or major instrumentation projects comprises two major components—the total estimated cost (TEC) and other project cost (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, OPC is costs 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.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Funds were provided in FY 2012 for other project costs associated with the NSLS-II at BNL.	7,700
FY 2013	The FY 2013 Request proposed $24,400,000 for other project costs associated with the NSLS-II at BNL according to the project plan. The increase would support the preparation for the startup of NSLS-II.	—
FY 2014	Funds are requested in FY 2014 for other project costs associated with the NSLS-II at BNL and with the LCLS-II at SLAC according to the project plan.	28,100

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Linac Coherent Light Source-II (LCLS-II)	0	—	700
National Synchrotron Light Source (NSLS-II)	7,700	—	27,400
Total, Other Project Costs	7,700	—	28,100

Major Items of Equipment

Overview

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 are required to 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.

Synchrotron Radiation Light Sources

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 3,500 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 GeV source in the U.S. and only one of three in the world, along with the European Synchrotron Radiation Facility (ESRF) in France and Spring-8 in Japan. The high-energy penetrating x-ray is especially critical for probing materials under real working environments, such as a battery or fuel cell in action. Both foreign facilities, commissioned at about the same time as the APS, are well into campaigns of major upgrades due to aging of beamlines as well as 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. The APS-U Project will upgrade the existing APS to provide an unprecedented combination of high-energy, high-average-brilliance, high flux, and short-pulse hard x-rays together with state-of-the-art x-ray beamline instrumentation. The APS-U's 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), which occupy different spectral, flux, and temporal range of technical specifications. The project is managed by Argonne National Laboratory.

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 operations of NSLS-II. The project is managed by Brookhaven National Laboratory.

High Flux Neutron Sources

The Spallation Neutron Source Instrumentation Next Generation-II (SING-II) MIE provides funding to fabricate four instruments, competitively selected using a peer review process, to be installed at the SNS. The project has an approved CD-2 Performance Baseline Total Project Cost of $60,000,000 and will complete the installation of these instruments on a phased schedule between FY 2012 and FY 2014. The SING-II instruments are in addition to the five instruments provided by the SING-I project.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	The APS-U Project entered the preliminary design phase post Critical Decision 1 (CD-1) and began preparations to attain approval for CD-2, which establishes the project baseline. The project sought and received approval for CD-3A in August 2012, which authorized long lead procurements	73,500
	After receiving CD-1 approval in October 2012 and CD-3A approval in February 2012, LCLS-II began work on design, in-house fabrication, long lead procurement (e.g., construction of an annex building, injector system, and undulator components), detailed design of the two-tunnel option, and project management.	
	The NEXT project achieved CD-1 in early 2012, which provides an alternative selection and cost range for this project and continued work on the preliminary design, working toward CD-2 approval early in FY 2013.	
	SING-II's four instruments received their last year of funding. The first instrument was completed	
FY 2013	The FY 2013 Request proposed $32,000,000 for APS-U and NEXT to continue design work and early procurements during FY 2013 and work toward achieving CD-3 approvals during FY 2013 and begin construction/fabrication of the technical scope. SING-II would continue fabrication of the neutron scattering instruments during FY 2013 with the possibility of an early finish for one or more.	—
	LCLS-II was included as a construction project in the FY 2013 request.	
FY 2014	APS-U is scheduled to request CD-3b approval in the 2Q FY 2014 and begin construction/fabrication of the technical scope. Design and procurement activities will continue in support of the Short-Pulse X-ray source development.	64,200
	NEXT is anticipated to receive CD-3 approval in 1Q FY 2014 and will continue design, procurements (long lead and regular), and begin construction/fabrication activities during FY 2014.	
	LCLS-II is included as a construction project in the FY 2014 request. No MIE funding is requested for this project.	

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Spallation Neutron Source Instrumentation II (SING II)	11,500	—	0
Advanced Photon Source Upgrade (APS-U)	20,000	—	39,200
Linac Coherent Light Source-II (LCLS-II)	30,000	—	0[a]
NSLS-II Experimental Tools (NEXT)	12,000	—	25,000
Total, Major Items of Equipment	73,500	—	64,200

[a] LCLS-II is moved to line item construction in the FY 2014 request.

Research

Overview

This activity supports three electron-beam microcharacterization centers, which operate as user facilities for scientific research and a platform for development of next-generation electron-beam instrumentation. These facilities provide unsurpassed spatial resolution and the ability to simultaneously obtain structural, chemical, and other types of information from sub-nanometer regions. The wide range of capabilities allows study of the fundamental mechanisms of catalysis, energy conversion, corrosion, charge transfer, magnetic behavior, and many other processes. All of these are fundamental to understanding and improving materials for energy applications and the associated physical characteristics and changes that govern performance. The three centers are the Electron Microscopy Center for Materials Research at Argonne National Laboratory (ANL), the National Center for Electron Microscopy at Lawrence Berkeley National Laboratory (LBNL), and the Shared Research Equipment user facility at Oak Ridge National Laboratory (ORNL).

This activity also supports basic research in accelerator physics and x-ray and neutron detectors. Accelerator research is the cornerstone for the development of new technologies that will improve performance of accelerator-based light sources and neutron spallation facilities. Research areas include ultrashort (attosecond) free electron lasers (FEL), 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 photocathodes 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. The emphasis of this activity is on research leading to a new and more efficient generation of 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 BNL and SLAC. Prior to FY 2014, this activity was funded by the DOE Environmental Management (EM) program.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	In FY 2012, funding was provided to support operations of the three electron beam microcharacterization centers and their corresponding user programs. FY 2012 funding was below the optimal level with likely impact on machine maintenance and user support. Triennial reviews of centers were conducted in FY 2012 to assess the facility performance, user operations, and the scientific output and impact. The results of the reviews demonstrated that these centers are highly productive with significant scientific impact. Accelerator physics and detector research continues to be supported at a reduced level. Research in developing superconducting accelerating cavities and cathode development was reduced. Support continued for the development of smart detectors, with concurrent signal processing capabilities, and solid state detectors optimized for next generation soft x-rays sources.	24,992

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2013	The FY 2013 Request proposed $27,000,000 that would support optimal operations of the three electron beam microcharacterization centers. The emphasis would have been on maintaining a robust user program at the three user facilities. The outcomes of the FY 2012 triennial reviews would be used to inform funding decisions and guide program development at the three centers. The accelerator physics and detector research would maintain a balanced portfolio that continue to push the frontiers in accelerator research in the generation of high-brightness electron beams, ultra-short x-ray pulses (of the order of sub-picoseconds and attoseconds) necessary for the exploration of the atomic structure of matter, and on the development of ultra-fast and high-precision detectors demanded by the high-flux, high-repetition rate of future light sources and neutron scattering facilities.	—
FY 2014	Funding is requested to support optimal operations of the three electron beam microcharacterization centers. The accelerator physics and detector research will maintain a balanced portfolio that continues to push the frontiers in accelerator and detector research in anticipation of advances in source output flux and data volume. Research activities on self-seeding and advanced accelerator methods will be continued. In FY 2014, responsibility is transferred from EM to BES for long term surveillance and maintenance (LTS&M) and for remaining legacy clean work scope at BNL and SLAC ($+12,873,000).	36,966

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Electron-Beam Microcharacterization	10,601	—	11,500
Accelerator and Detector Research	14,391	—	12,593
Long Term Surveillance and Maintenance	0	—	12,873
Total, Research	24,992	—	36,966

Construction
Funding Profile by Activity

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Linac Coherent Light Source-II (LCLS-II), SLAC	0	—[a]	95,000[b]
National Synchrotron Light Source-II (NSLS-II), BNL	151,400	152,327[c]	26,300
Total, Construction	151,400	152,327	121,300

[a] LCLS remains an MIE in FY 2013 under the CR.
[b] LCLS was funded as an MIE in FY 2012 and FY 2013.
[c] The FY 2013 amounts shown reflect the P.L. 112-175 continuing resolution level annualized to a full year. Pending finalization of FY 2013 funding levels, the TEC and TPC are based on the FY 2013 Request level of $47,203,000.

Overview

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.

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.

The new facilities that are currently under construction—the National Synchrotron Light Source-II (NSLS-II) and the Linac Coherent Light Source-II (LCLS-II)—will provide state-of-the-art scientific user facilities for the Nation's research community in a cost effective way. 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. LCLS-II will provide an increase in user capacity to LCLS, which offers unprecedented ultrafast coherent x-ray pulses for probing the dynamics of complex structures and their functions, and will also provide new scientific capabilities in both the hard and soft x-ray regimes.

Explanation of Funding Changes

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Linac Coherent Light Source-II (LCLS-II)	0	95,000	+95,000
Funding requested for continuation of engineering design and procurements. LCLS-II begins civil and conventional construction activities.			
National Synchrotron Light Source-II (NSLS-II)	151,400	26,300	-125,100
Funding requested for the civil construction will be ramped down, as scheduled.			
Total, Construction	151,400	121,300	-30,100

Supporting Information

Capital Operating Expenses

Capital Operating Expenses Summary

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Capital equipment over $500,000, including major items of equipment (MIEs)	77,093	—	69,510
General plant projects (GPP) (under $10 million)	3,202	—	600
Accelerator improvement projects (AIP)	13,400	—	16,500
Total, Capital Operating Expenses	93,695	—	86,610

Capital Equipment over $500,000 (including MIEs)

(dollars in thousands)

	Total	Prior Years	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Spallation Neutron Source Instrumentation-II, ORNL (TEC/TPC)	60,000	48,500	11,500	—	0
Advanced Photon Source Upgrade (APS-U), ANL (TEC/TPC)	388,500	0	20,000	—	39,200
Linac Coherent Light Source-II (LCLS-II), SLAC (TEC/TPC)		0	30,000	—	0[a]
NSLS-II Experimental Tools (NEXT), BNL (TEC/TPC)	90,000	0	12,000	—	25,000
Total, Major Items of Equipment (TEC/TPC)			73,500	—	64,200
Other capital equipment projects under $2 million TEC			3,593	—	5,310
Total, Capital equipment			77,093	—	69,510

[a] LCLS-II is requested as a line item construction project in FY 2014.

General Plant Projects (GPP) (TEC under $10 million)

(dollars in thousands)

	Total	Prior Years	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Ames Sensitive Instrument Facility	9,900	1,500	952[a]	—	0
Combustion Research Facility	9,500	4,000[b]	1,700	—	0
Other general plant projects under $5 million TEC	n/a	n/a	550	—	600
Total, General Plant Projects			3,202	—	600

Accelerator Improvement Projects (AIP)

(dollars in thousands)

	Total	Prior Years	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
LBNL Accelerator Controls	7,600	3,800	1,900	—	0
ORNL SNS Cryogenic Test Facility	5,609	3,452	2,157	—	0
Other accelerator improvement projects under $5 million TEC	n/a	n/a	9,343	—	16,500
Total, AIP			13,400	—	16,500

[a] An additional $3,048,000 of unobligated carryover was provided for this project in FY 2012.

[b] Funds in the amount of $2,550,000 were provided by the Energy Efficiency and Renewable program and Sandia National Laboratories.

Construction Projects Summary

Construction Projects

(dollars in thousands)

	Total	Prior Years	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
13-SC-10, Linac Coherent Light Source-II (LCLS-II), SLAC					
TEC	385,000	0	0	—	95,000
OPC	20,000	10,600	0	—	700
TPC	405,000[a]	10,600	0[b]	—[c]	95,700
07-SC-06, National Synchrotron Light Source-II, BNL					
TEC	791,200	566,297	151,400	152,327	26,300
OPC	120,800	61,300	7,700	7,747	27,400
TPC	912,000	627,597	159,100	160,074[d]	53,700
Total, Construction					
TEC			151,400	152,327	121,300
OPC			7,700	7,747	28,100
TPC			159,100	160,074	149,400

Construction Project Outyears

(dollars in thousands)

	FY 2015	FY 2016	FY 2017	FY 2018	Outyears to Completion
13-SC-10, Linac Coherent Light Source-II (LCLS-II), SLAC					
TEC	122,500	100,500	0	0	0
OPC	0	700	0	0	0
TPC	122,500	101,200	0	0	0

[a] This project is pre-CD-2; the funding estimate is preliminary.
[b] LCLS-II received $30,000,000 in FY 2012 as an MIE. This funding is included within the total TPC ($22,000,000 as TEC and $8,000,000 as OPC).
[c] FY 2013 funding was requested as a line item, but due to a Continuing Resolution the project is continuing as an MIE. The TEC, OPC, and TPC totals and outyear appropriation assumptions have not been adjusted to reflect the final FY 2013 level; the FY 2013 Request level of $63,500,000 for TEC and TPC and $0 for OPC are assumed instead.
[d] The FY 2013 amount shown reflects the P.L. 112-175 continuing resolution level annualized to a full year. The TEC, TPC, and outyear appropriation assumptions have not been adjusted to reflect this FY 2013 level; the FY 2013 Request level of $47,203,000 for TEC, $24,400,000 for OPC, and $71,603,000 for TPC is assumed.

Other Supporting Information

Funding Summary

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Research	676,522	—	763,276
Scientific User Facilities Operations	732,793	—	831,990
Major Items of Equipment	73,500	—	64,200
Construction Projects (includes OPC)	159,100	—	149,400
Other	2,852	—	53,545
Total, Basic Energy Sciences	1,644,767	1,698,424	1,862,411

Scientific User Facility Operations

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Synchrotron Radiation Light Source User Facilities			
Advanced Light Source, LBNL	63,200	—	63,700
Advanced Photon Source, ANL	123,265	—	130,000
National Synchrotron Light Source, BNL	36,000	—	35,000
National Synchrotron Light Source-II, BNL	0	—	69,000
Stanford Synchrotron Radiation Lightsource, SLAC	34,647	—	38,500
Linac Coherent Light Source (LCLS), SLAC	123,900	—	127,800
Total, Light Sources User Facilities	381,012	—	464,000
High-Flux Neutron Source User Facilities		—	
Spallation Neutron Source, ORNL	180,500	—	190,500
High Flux Isotope Reactor, ORNL	58,000	—	61,175
Lujan Neutron Scattering Center, LANL	10,500	—	9,815
Total, Neutron Source User Facilities	249,000	—	261,490

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Nanoscale Science Research Center User Facilities			
Center for Nanoscale Materials, ANL	20,500	—	21,300
Center for Functional Nanomaterials, BNL	20,000	—	21,300
Molecular Foundry, LBNL	20,500	—	21,300
Center for Nanophase Materials Sciences, ORNL	20,781	—	21,300
Center for Integrated Nanotechnologies, SNL/LANL	21,000	—	21,300
Total, Nanoscale Science Research Center User Facilities	102,781	—	106,500
Total, Scientific User Facility Operations	732,793	—	831,990

Facilities Users and Hours

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Advanced Light Source			
Achieved operating hours	5,359	—	N/A
Planned operating hours	4,800	—	5,300
Optimal hours	5,600	—	5,300[a]
Percent of optimal hours	96%	—	100%
Unscheduled downtime percentage	<10%	—	<10%
Number of users	1,995	—	2,050
Advanced Photon Source			
Achieved operating hours	4,969	—	N/A
Planned operating hours	5,000	—	5,000
Optimal hours	5,000	—	5,000
Percent of optimal hours	99%	—	100%
Unscheduled downtime percentage	<10%	—	<10%
Number of users	4,360	—	4,400

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
National Synchrotron Light Source			
Achieved operating hours	5,446	—	N/A
Planned operating hours	4,800	—	4,500
Optimal hours	5,400	—	4,500[a]
Percent of optimal hours	101%	—	100%
Unscheduled downtime percentage	<10%	—	<10%
Number of users	2,453	—	1,500
Stanford Synchrotron Radiation Lightsource			
Achieved operating hours	5,162	—	N/A
Planned operating hours	5,200	—	5,400
Optimal hours	5,400	—	5,400
Percent of optimal hours	96%	—	100%
Unscheduled downtime percentage	<10%	—	<10%
Number of users	1,597	—	1,500
Linac Coherent Light Source			
Achieved operating hours	4,098	—	N/A
Planned operating hours	4,300	—	3,000
Optimal hours	4,500	—	3,000[a]
Percent of optimal hours	91%	—	100%
Unscheduled downtime percentage	<10%	—	<10%
Number of users	571	—	350
High Flux Isotope Reactor			
Achieved operating hours	3,609	—	N/A
Planned operating hours	3,500	—	3,500
Optimal hours	4,500	—	3,500[b]
Percent of optimal hours	80%	—	100%
Unscheduled downtime percentage	<10%	—	<10%
Number of users	442	—	450

[a] The optimal hours for LCLS will be adjusted from 4,500 to 3,000 hours in FY 2014 due to planned activities relating to LCLS-II.

[b] The optimal hours for HFIR are adjusted from 4,500 to 3,500 hours in FY 2014 as the facility undergoes scheduled maintenance activities requiring shutdown.

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Lujan Neutron Scattering Center			
Achieved operating hours	2,241	—	N/A
Planned operating hours	3,000	—	2,000
Optimal hours	3,600	—	2,000[a]
Percent of optimal hours	62%	—	100%
Unscheduled downtime percentage	<10%	—	<10%
Number of users	249	—	250
Spallation Neutron Source			
Achieved operating hours	4,726	—	N/A
Planned operating hours	4,500	—	4,500
Optimal hours	4,900	—	4,500
Percent of optimal hours	96%	—	100%
Unscheduled downtime percentage	<10%	—	<10%
Number of users	799	—	850
Center for Nanoscale Materials[b]			
Number of users	444	—	400
Center for Functional Nanomaterials[b]			
Number of users	446	—	400
Molecular Foundry[b]			
Number of users	434	—	400
Center for Nanophase Materials Sciences[b]			
Number of users	409	—	400
Center for Integrated Nanotechnologies[b]			
Number of users	356	—	400
Total, All Facilities			
Achieved operating hours	35,610	—	N/A
Planned operating hours	35,100	—	34,200
Optimal hours	38,900	—	34,200
Percent of optimal hours (funding weighted)	94%	—	100%
Unscheduled downtime percentage	<10%	—	<10%
Number of users	14,555	—	13,350

[a] The optimal hours for Lujan are adjusted from 3,000 to 2,000 hours in FY 2014 due to major upgrades of the accelerators components to improve machine reliability.

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

Scientific Employment

	FY 2012 Actual	FY 2013 Estimate	FY 2014 Estimate
Number of university grants	1,050	—	1,120
Average size per year	230,000	—	230,000
Number of permanent Ph.D.'s (FTEs)	4,640	—	5,170
Number of postdoctoral associates (FTEs)	1,300	—	1,440
Number of graduate students (FTEs)	2,050	—	2,270

13-SC-10, Linac Coherent Light Source-II
SLAC National Accelerator Laboratory, Menlo Park, California
Project Data Sheet is for PED/Construction

1. Summary and Significant Changes

The most recent DOE O 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 Total Project Cost (TPC) range for this project is $350,000,000–$500,000,000. CD-0 (Approve Mission Need) was approved on April 22, 2010 and CD-1 (Approve Alternative Selection and Cost Range) was approved on October 14, 2011.

A Federal Project Director has been assigned to this project and is certified to level III.

This is an update of the FY 2013 PDS. FY 2013 funding was requested as a line item, but due to the Continuing Resolution, the project is continuing as an MIE in FY 2013. The preliminary TPC Range is unchanged.

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

(fiscal quarter or date)

	CD-0	CD-1	PED Complete	CD-2	CD-3A	CD-3B	CD-4	D&D Start	D&D Complete
FY 2013	4/22/2010	10/14/2011	4Q FY 2016[a]	1Q FY 2013[a]	3/14/2012[a]	3Q FY 2013[a]	4Q FY 2019[a]	N/A	N/A
FY 2014	4/22/2010	10/14/2011	4Q FY 2016[a]	4Q FY 2013[a]	3/14/2012[a]	4Q FY 2013[a]	4Q FY 2019[a]	N/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-3B – Approve Start of Construction
CD-4 – Approve Start of Operations or Project Closeout

3. Baseline and Validation Status

(dollars in thousands)

	TEC, PED	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	18,000[b]	367,000[b]	385,000[b]	20,000[b]	0	20,000[b]	405,000[c]

[a] This project is pre-CD-2; the estimated schedule is preliminary. Construction will not be executed without appropriate CD approvals.
[b] This project has not yet received CD-2 approval; funding estimates are preliminary. The preliminary TPC range for this project is $350,000,000–$500,000,000.
[c] The project was included in the FY 2012 Congressional Request as an MIE with a CD-0 cost range of $300,000,000–$400,000,000.

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 by extending performance into spectral regions not addressed by LCLS. The spectral range expansion will enable researchers to tackle new research frontiers that require even shorter or longer x-ray wavelengths; the capacity increase is critically needed as the demand for LCLS capabilities far exceeds the available time allocation to users. 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

LCLS is based on the existing SLAC linac. The linac was designed to accelerate electrons and positrons to 50 GeV for colliding beam experiments and for nuclear and high energy physics experiments on fixed targets. 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. When the LCLS-II is complete, the second kilometer of the linac will be used to produce high-brightness (13.5 GeV) electron bunches at a 120 hertz repetition rate. These electron bunches will be sent to a new undulator tunnel to produce two x-ray beams. The new soft x-ray (SXR) and hard x-ray (HXR) beams will span the tunable photon energy range beyond the existing LCLS facility. The new LCLS-II facilities will largely operate independently of the existing LCLS facility. When traveling through one of the new LCLS-II undulators, the electron bunches will amplify the emitted x-ray radiation to produce an intense, coherent (laser-like) x-ray beam for scientific research. At the completion of the LCLS-II project, the LCLS facilities will operate two independent electron linacs and three independent x-ray sources, supporting up to ten experiment stations.

LCLS used technologies developed at SLAC over many years of operation, as well as the world's brightest source of intense electron beams, producing extraordinary x-rays. SLAC's advances in the creation, compression, transport, and monitoring of bright electron beams have spawned a new generation of x-ray synchrotron 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, providing 10^{11} x-ray photons in a pulse with duration in the range 3–500 femtoseconds. These characteristics of the LCLS have opened new realms of research in the chemical, material, and biological sciences.

The LCLS-II project will construct a new 135 MeV injector to be installed at Sector 10 of the SLAC linac to create the electron beam required for an x-ray free-electron laser. This electron beam will be extracted from the linac near Sector 20, just upstream of the existing LCLS injector. The new electron beam will be transported in sectors 21–30 of the linac in a "bypass line," originally built for the PEP-II facility. Sectors 11–20 of the linac will be modified by adding two magnetic bunch compressors and the magnets guiding the electrons from the linac to the bypass line. Most of the existing linac and its infrastructure will remain unchanged.

The existing LCLS Beam Transport Hall will be expanded and extended to connect to the new undulator hall. This new hall will house the new SXR and HXR sources, electron beam dumps, and x-ray optics. The new Experimental Hall will be constructed for the exploitation of the new x-ray sources.

The combined characteristics (spectral content, peak power, pulse duration, and coherence) of the new SXR and HXR sources will surpass the present capabilities of the LCLS beam in spectral tuning range and brightness. 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 includes a comprehensive suite of instrumentation for characterization of the x-ray sources. Also included in the scope of the LCLS-II project are basic instrumentation and infrastructure necessary to support research at the LCLS facility.

Funding for conceptual design in FY 2011 supported the creation of a facility concept which has been reviewed and approved by DOE. The project initiated engineering design and long lead procurements in FY 2012. FY 2014 funding will continue design, additional site preparation, and begin construction and fabrication of technical equipment.

Key Performance Parameters

The key performance parameters the LCLS-II project must fulfill to achieve CD-4 Project Completion are listed below. These parameters are the minimum acceptable level of performance to mark the end of the project phase and do not represent the final or ultimate performance to be achieved by the project. It is anticipated that during operations following the project completion that most of the technical parameters below will be exceeded. These parameters are preliminary, pre-baseline values. The final key parameters will be established as part of CD-2 Performance Baseline.

Preliminary Key Parameters	Performance
Electron Beam Energy	12.0 GeV
Photon Beam Tuning Range	800–8,000 eV
Additional Space for Instruments	4 Experiment Stations
Facilities Gross Square Feet	>30,000 GSF

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	Costs
Total Estimated Cost (TEC)			
PED			
FY 2012	2,000[a]	2,000	2,000
FY 2013	—[b]	—	—
FY 2014	4,000	4,000	3,000
FY 2015	4,000	4,000	3,000
FY 2016	3,000	3,000	3,000
FY 2017	0	0	1,500
FY 2018	0	0	500
Total, PED	18,000[c]	18,000[c]	18,000[c]

[a] FY 2012 funding was requested as an MIE. FY 2012 funding was used for design and long lead procurement.
[b] The PED total and outyear appropriation assumptions have not been adjusted to reflect the final FY 2013 level; the FY 2013 Request level of $5,000,000 for PED is assumed instead.
[c] This project has not yet received CD-2 approval; funding estimates are preliminary. The preliminary TPC range for this project is $350,000,000–$500,000,000.

(dollars in thousands)

	Appropriations	Obligations	Costs
Construction			
FY 2012	20,000[a]	20,000	13,862
FY 2013	—[b]	—	—
FY 2014	91,000	91,000	75,200
FY 2015	100,000	100,000	91,400
FY 2016	97,500	97,500	90,800
FY 2017	0	0	32,150
FY 2018	0	0	4,700
FY 2019	0	0	838
Total, Construction	367,000[c]	367,000[c]	367,000[c]
TEC			
FY 2012	22,000[a]	22,000	15,862
FY 2013	—[b]	—	—
FY 2014	95,000	95,000	78,200
FY 2015	104,000	104,000	94,400
FY 2016	100,500	100,500	93,800
FY 2017	0	0	33,650
FY 2018	0	0	5,200
FY 2019	0	0	838
Total, TEC[c]	385,000[c]	385,000[c]	385,000[c]

[a] FY 2012 funding was requested as an MIE. FY 2012 funding was used for design and long lead procurement.

[b] The construction and TEC totals and outyear appropriation assumptions have not been adjusted to reflect the final FY 2013 level; the FY 2013 Request level of $58,500,000 for construction and $63,500,000 for TEC is assumed instead.

[c] This project has not yet received CD-2 approval; funding estimates are preliminary. The preliminary TPC range for this project is $350,000,000–$500,000,000.

(dollars in thousands)

	Appropriations	Obligations	Costs
Other Project Cost (OPC)			
OPC except D&D			
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	—[b]	—	—
FY 2014	700	700	500
FY 2015	0	0	450
FY 2016	700	700	500
FY 2017	0	0	536
Total, OPC	20,000[c]	20,000[c]	20,000[c]
Total Project Cost (TPC)			
FY 2010	1,126	1,126	938
FY 2011	9,474	9,474	8,033
FY 2012	30,000[a]	30,000	24,755
FY 2013	—[b]	—	—
FY 2014	95,700	95,700	78,700
FY 2015	104,000	104,000	94,850
FY 2016	101,200	101,200	94,300
FY 2017	0	0	34,186
FY 2018	0	0	5,200
FY 2019	0	0	838
Total, TPC[c]	405,000[c]	405,000[c]	405,000[c]

[a] FY 2012 funding was requested as an MIE. FY 2012 funding was used for design and long lead procurement.
[b] The OPC and TPC totals and outyear appropriation assumptions have not been adjusted to reflect the final FY 2013 level; the FY 2013 Request level of $0 for OPC and $63,500,000 for TPC are assumed instead.
[c] This project has not yet received CD-2 approval; funding estimates are preliminary. The preliminary TPC range for this project is $350,000,000–$500,000,000.

6. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
PED			
Design	16,500	14,500	N/A
Contingency	1,500	3,500	N/A
Total, PED	18,000[a]	18,000[a]	N/A
Construction			
Site Preparation	4,700	2,000	N/A
Equipment	189,370	188,752	N/A
Other Construction	95,243	86,048	N/A
Contingency	77,687	90,200	N/A
Total, Construction	367,000[a]	367,000[a]	N/A
Total, TEC	385,000[a]	385,000[a]	N/A
Contingency, TEC	79,187	93,700	N/A
Other Project Cost (OPC)			
OPC except D&D			
Conceptual Planning	1,126	1,126	N/A
Conceptual Design	14,974	11,974	N/A
Research and Development	1,100	1,100	N/A
Start-Up	1,920	1,200	N/A
Contingency	880	4,600	N/A
Total, OPC	20,000[a]	20,000[a]	N/A
Contingency, OPC	880	4,600	N/A
Total, TPC	405,000[a]	405,000[a]	N/A
Total, Contingency	80,067	98,300	N/A

[a] This project has not yet received CD-2 approval; funding estimates are preliminary. The preliminary TPC range for this project is $350,000,000–$500,000,000.

7. Schedule of Appropriations Requests

Request Year		Prior Years	FY 2012	FY 2013	FY 2014	FY 2015	FY2016	FY2017	Total
		(dollars in thousands)							
FY2012 (MIE)	TEC	0	22,000	TBD	TBD	TBD	TBD	TBD	TBD
	OPC	10,600	8,000	TBD	TBD	TBD	TBD	TBD	TBD
	TPC	10,600	30,000	TBD	TBD	TBD	TBD	TBD	TBD
FY2013	TEC	0	22,000	63,500	80,300	94,000	105,300	19,900	385,000
	OPC	10,600	8,000	0	700	0	700	0	20,000
	TPC	10,600	30,000	63,500	81,000	94,000	106,000	19,900	405,000
FY2014	TEC	0	22,000	—	95,000	104,000	100,500	0	385,000
	OPC	10,600	8,000	—	700	0	700	0	20,000
	TPC	10,600	30,000	—[a]	95,700	104,000	101,200	0	405,000[b]

8. Related Operations and Maintenance Funding Requirements

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

9. Required D&D Information

Area of New Construction: The LCLS-II project will construct new facilities (on-grade enclosures, tunnels, experimental hall and service building) ranging from 30,000 to 59,000 sf.

Area of Existing Facility(s) 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 project was completed and reviewed. Key design activities were specified for the undulator to reduce schedule risk to the project and expedite the startup. Also, the project management systems put in place and tested during the first LCLS Project have been updated and are now maintained as a SLAC-wide resource. Lawrence Berkeley National Laboratory (LBNL) is an institutional partner to SLAC in the LCLS-II Project, with responsibility for design and construction of the necessary high-performance variable gap undulators.

Technical systems design (injector, linac, bunch compressors, transport lines through the undulators) are heavily based on designs from LCLS. Cost estimates for these systems are based on actual costs from LCLS. The availability of reliable, recent cost data has been exploited fully in planning and budgeting for the LCLS-II Project. Design of the technical systems will be

[a] FY 2013 funding was requested as a line item, but due to a Continuing Resolution the project is continuing as an MIE. The TEC, OPC, and TPC totals and outyear appropriation assumptions have not been adjusted to reflect the final FY 2013 level; the FY 2013 Request level of $63,500,000 for TEC and TPC and $0 for OPC are assumed instead.

[b] This project has not yet received CD-2 approval; funding estimates are preliminary. The preliminary TPC range for this project is $350,000,000–$500,000,000.

completed by SLAC or LBNL staff. Technical equipment will either be fabricated in-house or subcontracted to vendors with the necessary capabilities.

The conventional construction design, including the tunnels for the undulator and experimental facilities, are heavily based on the designs used successfully in the original LCLS Project. The conventional construction design is subcontracted to an experienced Architect/Engineering firm to perform Title I and II design. An experienced General Contractor will be hired to carry out conventional facilities construction.

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.

07-SC-06, National Synchrotron Light Source II (NSLS-II)
Brookhaven National Laboratory, Upton, New York
Project Data Sheet is for PED/Construction

1. Summary and Significant Changes

The most recent DOE O 413.3B approved Critical Decision (CD) is CD-3, Start of Construction, which was approved on January 9, 2009, with a Total Project Cost (TPC) of $912,000,000 and a planned CD-4 of June, 2015.

The Federal Project Director is certified at level 4.

This PDS is an update of the FY 2013 PDS.

To support a targeted early project finish, the funding profile has changed from FY 2013 PDS. The change is to move $5,000,000 in Other Project Costs (OPC) from FY 2015 into FY 2014. This will allow optimum project performance in the final year of construction.

The approximate square footage of new construction space was changed from 400,000 to 600,000 square feet to recognize approved baseline changes to authorize widening of the experimental floor and the addition of two Laboratory Office Buildings (LOBs).

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

(fiscal quarter or date)

	CD-0	CD-1	Performance Baseline Validation	(PED Complete)	CD-2	CD-3	CD-4
FY 2007	08/25/2005	1Q FY 2007	N/A	4Q FY 2008	TBD	TBD	TBD
FY 2008	08/25/2005	2Q FY 2007	N/A	2Q FY 2009	TBD	TBD	TBD
FY 2009	08/25/2005	07/12/2007	12/11/2007	2Q FY 2009	2Q FY 2008	2Q FY 2009	3Q FY 2015
FY 2010	08/25/2005	07/12/2007	12/11/2007	2Q FY 2009	01/18/2008	01/09/2009	3Q FY 2015
FY 2011	08/25/2005	07/12/2007	12/11/2007	4Q FY 2010	01/18/2008	01/09/2009	3Q FY 2015
FY 2012	08/25/2005	07/12/2007	12/11/2007	4Q FY 2011	01/18/2008	01/09/2009	3Q FY 2015
FY 2013	08/25/2005	07/12/2007	12/11/2007	09/30/2011	01/18/2008	01/09/2009	3Q FY 2015
FY 2014	08/25/2005	07/12/2007	12/11/2007	09/30/2011	01/18/2008	01/09/2009	3Q FY 2015

CD-0 – Approve Mission Need
CD-1 – Approve Alternative Selection and Cost Range
CD-2 – Approve Performance Baseline
CD-3 – Approved Start of Construction
CD-4 – Approve Project Completion
D&D Start – Start of Demolition & Decontamination (D&D) work, not applicable to this project
D&D Complete – Completion of D&D work, not applicable to this project

3. Baseline and Validation Status

(dollars in thousands)

	TEC, PED	TEC, Construction	TEC, Total	OPC Except D&D	OPC D&D	OPC, Total	TPC
FY 2007	75,000	TBD	TBD	TBD	TBD	TBD	TBD
FY 2008	75,000	TBD	TBD	TBD	TBD	TBD	TBD
FY 2009	60,000	731,200	791,200	120,800	0	120,800	912,000
FY 2010	60,000	731,200	791,200	120,800	0	120,800	912,000
FY 2011	60,000	731,200	791,200	120,800	0	120,800	912,000
FY 2012	60,000	731,200	791,200	120,800	0	120,800	912,000
FY 2013	60,000	731,200	791,200	120,800	0	120,800	912,000
FY 2014	60,000	731,200	791,200	120,800	0	120,800	912,000

4. Project Description, Scope, and Justification

Mission Need

Major advances in energy technologies will require scientific breakthroughs in developing new materials with advanced properties. A broad discussion is given in several recent reports, including the Basic Energy Sciences (BES) Advisory Committee reports entitled *Opportunities for Catalysis in the 21st Century*, *Basic Research Needs to Assure a Secure Energy Future*, *Basic Research Needs for the Hydrogen Economy*, and *Basic Research Needs for Solar Energy Utilization*, in addition to the Nanoscale Science, Engineering, and Technology Subcommittee of the National Science and Technology Committee report entitled *Nanoscience Research for Energy Needs*.

Collectively, these reports underscore the need to develop new tools that will allow the characterization of the atomic and electronic structure, the chemical composition, and the magnetic properties of materials with nanoscale resolution. Non-destructive tools are needed to image and characterize structures and interfaces below the surface, and these tools must operate in a wide range of temperature and harsh environments. The 1999 BES report *Nanoscale Science, Engineering, and Technology Research Directions* identified the absence of any tool possessing these combined capabilities as a key barrier to progress.

In order to fill this capability gap, the Office of Science determined that its mission requires a synchrotron light source that will enable the study of material properties and functions, particularly materials at the nanoscale, at a level of detail and precision never before possible. Only x-ray methods have the potential of satisfying all of these requirements, but advances both in x-ray optics and in x-ray brightness and flux are required to achieve a spatial resolution of 1 nm and an energy resolution of 0.1 meV. Ultimately, the ring is expected to operate a stored electron beam current of 500 mA at 3.0 GeV.

Scope and Justification for 07-SC-06 National Synchrotron Light Source II

An alternatives analysis found no existing light sources in the U.S. could fulfill the requirements identified above. There are no alternative tools with a spatial resolution of 1 nm and energy resolution of 0.1 meV that also have the required capabilities of being non-destructive and able to image and characterize buried structures and interfaces in a wide range of temperatures and harsh environments. In the case of NSLS-I, it was found that it would be impossible to upgrade this light source due to numerous technical difficulties, including accelerator physics and infrastructure constraints, such as its small circumference, which limit the feasible in-place upgrade options. The decision was made to design and build a new synchrotron facility.

The National Synchrotron Light Source II (NSLS-II) will be a new synchrotron light source, highly optimized to deliver ultra-high brightness and flux and exceptional beam stability. It will also provide advanced insertion devices, optics, detectors, robotics, and an initial suite of scientific instruments. Together, these will enable the study of material properties and functions with a spatial resolution of about 1 nm, an energy resolution of about 0.1 meV, and the ultra-high sensitivity required to perform spectroscopy on a single molecule.

The NSLS-II project will design, build, and install the accelerator hardware, experimental apparatus, civil construction, and central facilities including offices and laboratories required to produce a new synchrotron light source. It includes a third generation storage ring, full energy injector, experimental areas, an initial suite of scientific instruments, and appropriate support equipment, all housed in a new building.

Key Performance Parameters

Key Parameters	Performance
Accelerator Facilities:	
Electron Energy	3.0 GeV
Stored Current	25 mA
Conventional Facilities: Building Area	>340,000 GSF
Experimental Facilities: Beamlines installed and ready for commissioning with X-ray beam	6

The key performance parameters are defined in the project execution plan. The NSLS-II project is expected to deliver an electron energy of 3.0 GeV with a stored current of 25 milliamps; build a third generation storage ring of approximately one half mile in circumference and experimental and operations facilities with a total conventional construction of approximately 600 thousand gross square feet, and include an initial suite of six beamlines ready for commissioning with x-ray beam. These are the minimum performance requirements to achieve CD-4.

Current Status

As of December 2012, the project is 84.90% complete. The cumulative cost and schedule performance indices are 0.99 and 0.95 respectively, both well within the BES performance goal of 0.90 to 1.10. Conventional construction activities continue to wind down as the contractors work through the remaining punchlist items and demobilize. All five Lab-Office Buildings (LOBs) have been completed. The installation and commissioning of the Linac has been completed. The installation of the booster, storage ring magnet-girders, and transfer lines is nearly complete. A total of 142 of 150 storage ring magnet girders have been installed. Storage ring magnet production is complete. A number of design reviews for major beamline component contracts were conducted and hutch fabrication and installation continues.

During FY 2013 the project will continue with the fabrication/procurement of remaining components for accelerator systems, experimental systems and the infrastructure. Installation of accelerator and experimental systems will continue, along with system post installation testing. Commissioning of the accelerator systems follows installation. The Booster commissioning is expected to begin in 4Q FY2013. The target date for storage ring commissioning is 1Q FY 2014. Fully commissioned systems will be transitioned to operations and supported by early operation funds (off project).

During FY 2014 the project will focus on the startup and commissioning of the storage ring and remaining accelerator systems, completion of the project beamlines and the transition to operations in anticipation of an early finish. The target early finish date remains June 2014 with CD-4 in June 2015.

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	Recovery Act Costs	Costs
Total Estimated Cost (TEC)				
PED				
FY 2007	3,000	3,000	0	2,292
FY 2008	29,727	29,727	0	28,205
FY 2009	27,273	27,273	0	23,044
FY 2010	0	0	0	6,173
FY 2011	0	0	0	286
Total, PED	60,000	60,000	0	60,000
Construction				
FY 2009	66,000	66,000	0	24,092
FY 2009 Recovery Act	150,000	150,000	14,751	0
FY 2010	139,000	139,000	67,424	84,826
FY 2011	151,297	151,297	42,322	162,091
FY 2012	151,400	151,400	22,391	150,597
FY 2013	152,327[a]	47,203	3,112	104,499
FY 2014	26,300	26,300	0	46,831
FY 2015	0	0	0	8,264
Total, Construction	731,200	731,200	150,000	581,200

[a] The FY 2013 amount shown reflects the P.L. 112-175 continuing resolution level annualized to a full year. The TEC total is based on the FY 2013 Request level of $47,203,000 instead.

	(dollars in thousands)			
	Appropriations	Obligations	Recovery Act Costs	Costs
TEC				
FY 2007	3,000	3,000	0	2,292
FY 2008	29,727	29,727	0	28,205
FY 2009	93,273	93,273	0	47,136
FY 2009 Recovery Act	150,000	150,000	14,751	0
FY 2010	139,000	139,000	67,424	90,999
FY 2011	151,297	151,297	42,322	162,377
FY 2012	151,400	151,400	22,391	150,597
FY 2013	152,327[a]	47,203	3,112	104,499
FY 2014	26,300	26,300	0	46,831
FY 2015	0	0	0	8,264
Total, TEC	791,200	791,200	150,000	641,200
Other Project Cost (OPC)				
OPC except D&D				
FY 2005	1,000	1,000	0	0
FY 2006	4,800	4,800	0	4,958
FY 2007	22,000	22,000	0	20,461
FY 2008	20,000	20,000	0	15,508
FY 2009	10,000	10,000	0	7,101
FY 2010	2,000	2,000	0	5,852
FY 2011	1,500	1,500	0	4,575
FY 2012	7,700	7,700	0	6,705
FY 2013	7,747[b]	24,400	0	24,965
FY 2014	27,400	27,400	0	29,251
FY 2015	0	0	0	1,424
Total, OPC	120,800	120,800	0	120,800

[a] The FY 2013 amount shown reflects the P.L. 112-175 continuing resolution level annualized to a full year. The TEC total is based on the FY 2013 Request level of $47,203,000 instead.

[b] The FY 2013 amount shown reflects the P.L. 112-175 continuing resolution level annualized to a full year. The OPC total is based on the FY 2013 Request level of $24,400,000 instead.

(dollars in thousands)

	Appropriations	Obligations	Recovery Act Costs	Costs
Total Project Cost (TPC)				
FY 2005	1,000	1,000	0	0
FY 2006	4,800	4,800	0	4,958
FY 2007	25,000	25,000	0	22,753
FY 2008	49,727	49,727	0	43,713
FY 2009	103,273	103,273	0	54,237
FY 2009 Recovery Act	150,000	150,000	14,751	0
FY 2010	141,000	141,000	67,424	96,851
FY 2011	152,797	152,797	42,322	166,952
FY 2012	159,100	159,100	22,391	157,302
FY 2013	160,074[a]	71,603	3,112	129,464
FY 2014	53,700	53,700	0	76,082
FY 2015	0	0	0	9,688
Total, TPC	912,000	912,000	150,000	762,000

6. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
PED			
Design	60,000	60,000	49,000
Contingency	0	0	11,000
Total, PED	60,000	60,000	60,000

[a] The FY 2013 amount shown reflects the P.L. 112-175 continuing resolution level annualized to a full year. The TPC total is based on the FY 2013 Request level of $71,603,000 instead.

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Construction			
Site Preparation	9,243	9,243	9,243
Equipment	31,579	31,579	31,579
Other Construction	628,551	618,003	518,381
Contingency	61,827	72,375	171,997
Total, Construction	731,200	731,200	731,200
Total, TEC	791,200	791,200	791,200
Contingency, TEC	61,827	72,375	182,997
Other Project Cost (OPC)			
Conceptual Planning	24,800	24,800	24,800
Research and Development	35,800	35,800	35,800
Start-Up	51,601	50,200	50,200
Contingency	8,599	10,000	10,000
Total, OPC	120,800	120,800	120,800
Contingency, OPC	8,599	10,000	10,000
Total, TPC	912,000	912,000	912,000
Total, Contingency	70,426	82,375	192,997

7. Schedule of Appropriation Requests

(dollars in thousands)

Request Year		Prior Years	FY 2009	FY 2009 Recovery Act	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	Total
FY 2007[a]	TEC	75,000	0	0	0	0	0	0	0	0	75,000
	OPC	46,000	0	0	0	0	0	0	0	0	46,000
	TPC	121,000	0	0	0	0	0	0	0	0	121,000
FY 2008[a]	TEC	65,000	10,000	0	0	0	0	0	0	0	75,000
	OPC	50,800	0	0	0	0	0	0	0	0	50,800
	TPC	115,800	10,000	0	0	0	0	0	0	0	125,800

[a] The FY 2007 and FY 2008 requests were for PED funding only.

Request Year		Prior Years	FY 2009	FY 2009 Recovery Act	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	Total
		(dollars in thousands)									
FY 2009[a]	TEC	32,727	93,273	0	162,500	252,900	166,100	57,400	26,300	0	791,200
	OPC	47,800	10,000	0	2,000	1,500	7,700	24,400	22,400	5,000	120,800
	TPC	80,527	103,273	0	164,500	254,400	173,800	81,800	48,700	5,000	912,000
FY 2010	TEC	32,727	93,273	150,000	139,000	151,600	151,400	46,900	26,300	0	791,200
	OPC	47,800	10,000	0	2,000	1,500	7,700	24,400	22,400	5,000	120,800
	TPC	80,527	103,273	150,000	141,000	153,100	159,100	71,300	48,700	5,000	912,000
FY 2011	TEC	32,727	93,273	150,000	139,000	151,600	151,400	46,900	26,300	0	791,200
	OPC	47,800	10,000	0	2,000	1,500	7,700	24,400	22,400	5,000	120,800
	TPC	80,527	103,273	150,000	141,000	153,100	159,100	71,300	48,700	5,000	912,000
FY 2012	TEC	32,727	93,273	150,000	139,000	151,600	151,400	46,900	26,300	0	791,200
	OPC	47,800	10,000	0	2,000	1,500	7,700	24,400	22,400	5,000	120,800
	TPC	80,527	103,273	150,000	141,000	153,100	159,100	71,300	48,700	5,000	912,000
FY 2013	TEC	32,727	93,273	150,000	139,000	151,297	151,400	47,203	26,300	0	791,200
	OPC	47,800	10,000	0	2,000	1,500	7,700	24,400	22,400	5,000	120,800
	TPC	80,527	103,273	150,000	141,000	152,797	159,100	71,603	48,700	5,000	912,000
FY 2014	TEC	32,727	93,273	150,000	139,000	151,297	151,400	152,327	26,300	0	791,200
	OPC	47,800	10,000	0	2,000	1,500	7,700	7,747	27,400	0	120,800
	TPC	80,527	103,273	150,000	141,000	152,797	159,100	160,047	53,700	0	912,000

8. Related Operations and Maintenance Funding Requirements

Beneficial occupancy of the experimental floor:	February 2012
Expected useful life (number of years):	25
Expected future start of D&D of this capital asset (fiscal quarter):	N/A

[a] FY 2009 reflects the original validated funding baseline.

[b] 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 are based on the FY 2013 Request levels of $47,203,000, $24,400,000, and $71,603,000 instead.

(Related Funding Requirements)

	(dollars in thousands)			
	Annual Costs		Life cycle costs	
	Current Total Estimate	Previous Total Estimate	Current Total Estimate	Previous Total Estimate
Operations	119,400	119,400	4,470,000	4,470,000
Maintenance	21,100	21,100	789,000	789,000
Total Operations and Maintenance	140,500	140,500	5,259,000	5,259,000

9. Required D&D Information

	Square Feet
Area of new construction:	Approximately 600,000
Area of existing facilities being replaced:	N/A
Area of any additional space that will require D&D to meet the "one-for-one" requirement:	N/A (see below)

The existing facility (NSLS) will be converted to another use. The one-for-one replacement has been met through completed and planned elimination of space at Brookhaven National Laboratory (BNL) along with "banked" space at the Massachusetts Institute of Technology (MIT) in Middleton, MA, and at the East Tennessee Technology Park (ETTP) in Oak Ridge, TN. A waiver from the one-for-one requirement to eliminate excess space at Brookhaven to offset the NSLS-II project was approved by Secretary Bodman on April 20, 2007. The waiver identified approximately 460,000 square feet of banked excess facilities space that was eliminated in FY 2006 at MIT and ETTP. This approved banked excess space, in addition to eliminated space at BNL, exceeds the addition of space by NSLS-II.

10. Acquisition Approach

The acquisition strategy selected relies on the BNL management and operating (M&O) contractor to directly manage the NSLS-II acquisition. The acquisition of large research facilities is within the scope of the DOE contract for the management and operation of BNL.

The design, fabrication, assembly, installation, testing, and commissioning of the NSLS-II project will largely be performed by the BNL NSLS-II scientific and technical staff. Much of the subcontracted work to be performed for NSLS-II consists of hardware fabrication and conventional facilities construction. Each system or component will be procured using fixed price contracts, unless there is a compelling reason to employ another contract type. Best-value competitive procurements will be employed to the maximum extent possible.

Many major procurements are either build-to-print, following BNL/NSLS-II drawings and specifications, or readily available off-the-shelf. Source selection will be carried out in accordance with DOE-approved policies and procedures. Acquisition strategies have been chosen and will continue to obtain the best value based on the assessment of technical and cost risks on a case-by-case basis. For standard, build-to-print fabrications and the purchase of off-the-shelf equipment for routine applications, available purchasing techniques include price competition among technically qualified suppliers and use of competitively awarded blanket purchase agreements are used.

The architect-engineer (A-E) subcontract was placed on a firm-fixed-price basis for the Final (Title II) Design and (Title III) construction support services. The general construction subcontract was also placed on a firm-fixed-price basis. The design specifications are detailed and allow prospective constructors to formulate firm-fixed-price offers without excessive contingency and allowances.

NSLS-II project management has identified major procurements that represent significant complexity or cost and schedule risk. Advance procurement plans (APPs) have been prepared for each major procurement. The APPs include discussion of contract type, special contracting methods, special clauses or deviations required, and lease or purchase decisions. These final APPs will identify critical procurement activities and help to mitigate or avoid schedule conflicts and other procurement-related problems. At appropriate dollar levels, the APPs are approved by the responsible Division Director, the NSLS-II Procurement Manager, the NSLS-II Deputy Director, the NSLS-II Project Director and the DOE Site Office.

Project performance metrics for BNL are included in the M&O contractor's annual performance evaluation and measurement plan.