DOE/CF-0074
Volume 4

Department of Energy
FY 2013 Congressional Budget Request

Science
Advanced Research Projects Agency-Energy

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The Department of Energy's Congressional Budget justification is available on the Office of Chief Financial Officer, Office of Budget homepage at http://www.cfo.doe.gov/crorg/cf30.htm.

DEPARTMENT OF ENERGY
Appropriation Account Summary
(dollars in thousands - OMB Scoring)

	FY 2011 Current	FY 2012 Enacted [1]	FY 2013 Request	FY 2013 vs. FY 2012	
				$	%
Energy And Water Development, And Related Agencies					
Appropriation Summary					
Energy Programs					
Energy Efficiency and Renewable Energy	1,771,721	1,809,638	2,337,000	+527,362	+29.1%
Electricity Delivery and Energy Reliability	138,170	139,103	143,015	+3,912	+2.8%
Nuclear Energy	717,817	765,391	770,445	+5,054	+0.7%
Fossil Energy Programs					
Clean Coal Technolgy	-16,500	0	0	0	0
Fossil Energy Research and Development	434,052	346,703	420,575	+73,872	+21.3%
Naval Petroleum and Oil Shale Reserves	20,854	14,909	14,909	0	N/A
Elk Hills School Lands Fund	0	0	15,580	+15,580	+100.0%
Strategic Petroleum Reserve	123,141	192,704	195,609	+2,905	+1.5%
Northeast Home Heating Oil Reserve	10,978	10,119	4,119	-6,000	-59.3%
Subtotal, Fossil Energy Programs	***572,525***	***564,435***	***650,792***	**+86,357**	**+15.3%**
Uranium Enrichment D&D Fund	497,084	472,180	442,493	-29,687	-6.3%
Energy Information Administration	95,009	105,000	116,365	+11,365	+10.8%
Non-Defense Environmental Cleanup	225,106	235,306	198,506	-36,800	-15.6%
Science	4,897,283	4,873,634	4,992,052	+118,418	+2.4%
Advanced Research Projects Agency-Energy	179,640	275,000	350,000	+75,000	+27.3%
Nuclear Waste Disposal	-2,800	0	0	0	0
Departmental Administration	48,894	126,000	122,595	-3,405	-2.7%
Inspector General	42,764	42,000	43,468	+1,468	+3.5%
Innovative Technology Loan Guarantee Program	169,660	0	0	0	0
Advanced Technology Vehicles Manufacturing Loan	9,978	6,000	9,000	+3,000	+50.0%
Total, Energy Programs	***9,362,851***	***9,413,687***	***10,175,731***	**+762,044**	**+8.1%**
Atomic Energy Defense Activities					
National Nuclear Security Administration:					
Weapons Activities	6,865,775	7,214,120	7,577,341	363,221	+5.0%
Defense Nuclear Nonproliferation	2,281,371	2,295,880	2,458,631	162,751	+7.1%
Naval Reactors	985,526	1,080,000	1,088,635	8,635	+0.8%
Office of the Administrator	393,293	410,000	411,279	1,279	+0.3%
Total, National Nuclear Security Administration	***10,525,965***	***11,000,000***	***11,535,886***	**+535,886**	**+4.9%**
Environmental and Other Defense Activities					
Defense Environmental Cleanup	4,979,165	5,002,950	5,472,001	+469,051	+9.4%
Other Defense Activities	795,670	823,364	735,702	-87,662	-10.6%
Total, Environmental & Other Defense Activities	***5,774,835***	***5,826,314***	***6,207,703***	**+381,389**	**+6.5%**
Total, Atomic Energy Defense Activities	***16,300,800***	***16,826,314***	***17,743,589***	**+917,275**	**+5.5%**
Power Marketing Administration					
Southwestern Power Administration	13,050	11,892	11,892	0	0
Western Area Power Administration	109,006	95,968	96,130	+162	+0.2%
Falcon & Amistad Operating & Maintenance Fund	220	220	220	0	0
Colorado River Basins	-23,000	-23,000	-23,000	0	0
Total, Power Marketing Administrations	***99,276***	***85,080***	***85,242***	**+162**	**+0.2%**
Subtotal, Energy And Water Development and Related Agencies	***25,762,927***	***26,325,081***	***28,004,562***	**+1,679,481**	**+6.4%**
Uranium Enrichment D&D Fund Discretionary Payments	-33,633	0	-463,000	-463,000	N/A
Excess Fees and Recoveries, FERC	-36,461	-25,534	-25,823	-289	-1.1%
Rescission of Balances	0	0	-360,667	-360,667	N/A
Total, Discretionary Funding by Appropriation	**25,692,833**	**26,299,547**	**27,155,072**	**+855,525**	**+3.2%**

[1] The FY 2012 Enacted reflects a rescission of $73,300 associated with savings from the contractor pay freeze; $600M ($500M Strategic Petroleum Reserve, $100M Northeast Home Heating Oil) was rebased as mandatory after enactment.

Science

Science

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Science
Proposed Appropriation Language

For Department of Energy expenses including the purchase, construction, and acquisition of plant and capital equipment, and other expenses necessary for science activities in carrying out the purposes of the Department of Energy Organization Act (42 U.S.C. 7101 et seq.), including the acquisition or condemnation of any real property or facility or for plant or facility acquisition, construction, or expansion, and purchase of not more than 25 passenger motor vehicles for replacement only, including one ambulance and two buses, $4,992,052,000, to remain available until expended: Provided, That $202,551,000 shall be available until September 30, 2014 for program direction.

Explanation of Change

Appropriation language updates reflect the funding and replacement passenger motor vehicle levels requested in FY 2013.

Science
Office of Science

Overview
Appropriation Summary by Program

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Advanced Scientific Computing Research[a]	410,317	440,868	455,593
Basic Energy Sciences[a]	1,638,511	1,688,093	1,799,592
Biological and Environmental Research[a]	595,246	609,557	625,347
Fusion Energy Sciences[a]	367,257	400,996	398,324
High Energy Physics[a]	775,578	790,860	776,521
Nuclear Physics[a]	527,684	547,387	526,938
Workforce Development for Teachers and Scientists	22,600	18,500	14,500
Science Laboratories Infrastructure	125,748	111,800	117,790
Safeguards and Security[a]	83,786	80,573	84,000
Program Direction[a]	202,520	185,000	202,551
Small Business Innovation Research/Technology Transfer (SBIR/STTR) (SC funding)	108,418	0	0
Subtotal, Office of Science	4,857,665	4,873,634	5,001,156
SBIR/STTR (Other DOE funding)	54,618	0	0
Use of prior year balances	-15,000	0	-9,104
Total, Science appropriation/Office of Science	4,897,283	4,873,634[b]	4,992,052

[a] Funding includes support for the Working Capital Fund (WCF). DOE is working to achieve economies of scale through the WCF. The WCF covers certain shared, enterprise activities including enhanced cyber security architecture, employee health and testing services, and consolidated training and recruitment initiatives.
[b] The FY 2012 appropriation is reduced by $15,366,000 for the Office of Science share of the DOE-wide $73,300,000 rescission for contractor pay freeze savings. The FY 2013 budget request reflects the FY 2013 impact of the contractor pay freeze.

Office Overview and Accomplishments

The Office of Science mission is to deliver the scientific discoveries and major scientific tools that transform our understanding of nature and advance the energy, economic, and national security of the United States. The Office of Science accomplishes its mission and advances national goals by supporting:

- Energy and Environmental Science, focused on advancing a clean energy agenda through fundamental research on energy production, storage, transmission, and use, and on advancing our understanding of the earth's climate through basic research in atmospheric and environmental sciences and climate change; and
- The Frontiers of Science, focused on unraveling nature's mysteries—from the study of subatomic particles, atoms, and molecules that make of the materials of our everyday world to DNA, proteins, cells, and entire biological systems;

- The 21st Century Tools of Science, national scientific user facilities providing the Nation's researchers with the most advanced tools of modern science including accelerators, colliders, supercomputers, light sources, neutron sources, and facilities for studying the nanoworld.

The Office of Science has long been a leader of U.S. scientific discovery and innovation. Over the decades, Office of Science investments have driven the modern biotechnology revolution and the transition in the 20th century from observing natural phenomena to the science of control and directed design at the nanoscale. We have pushed the frontiers of our understanding of the origins of matter and the universe, and we have built and operated the large-scale scientific facilities that collectively form a major pillar of the current U.S. scientific enterprise. These investments and accomplishments have led to new technologies and created new businesses and industries, making significant contributions to our Nation's economy and quality of life.

The Office of Science is the lead Federal agency supporting fundamental scientific research for energy and the Nation's largest Federal sponsor of basic research in the physical sciences. The Office of Science supports about 25,000 investigators at about 300 U.S. academic institutions and at all of the DOE laboratories. The Office of Science also provides the Nation's researchers with state-of-the-art national scientific user facilities—the large machines for modern science. These facilities offer capabilities unmatched anywhere in the world and enable U.S. researchers and industries to remain at the forefront of science, technology, and innovation. Approximately 26,500 researchers from universities, national laboratories, industry, and international partners are expected to use the Office of Science scientific user facilities in FY 2013.

Significant accomplishments during FY 2011, described in more detail in the program narratives that follow, include demonstrating self-repair in a bio-inspired artificial solar cell; creating novel designs for memory systems and interconnects to accelerate computer speeds while decreasing their energy demand; engineering microbes to directly convert plant material into a drop-in biofuel; and discovering that the neutrons occupy a larger volume than the protons in Pb-208, a result central to understanding the structure of heavy nuclei.

Complete descriptions of several science discoveries of FY 2011 can be found at http://science.energy.gov/stories-of-discovery-and-innovation/.

The Office of Science appropriation includes ten programs:

- *Advanced Scientific Computing Research* supports research to discover, develop, and deploy the computational and networking capabilities to analyze, model, simulate, and predict complex phenomena important to DOE.
- *Basic Energy Sciences* supports fundamental research to understand, predict, and ultimately control matter and energy at the electronic, atomic, and molecular levels in order to provide the foundations for new energy technologies and to support the DOE mission in energy, environment, and national security.
- *Biological and Environmental Research* supports fundamental research to address diverse and critical global challenges, from the sustainable and affordable production of renewable biofuels to understanding and predicting climate change and greenhouse gas emissions relevant to energy production and technology use.
- *Fusion Energy Sciences* supports research to expand the fundamental understanding of matter at very high temperatures and densities and to build the scientific foundation of fusion energy.
- *High Energy Physics* supports research toward understanding how the universe works at its most fundamental level by discovering the most elementary constituents of matter and energy, probing the interactions among them, and exploring the basic nature of space and time itself.
- *Nuclear Physics* supports research to discover, explore, and understand all forms of nuclear matter, supporting experimental and theoretical research to create, detect, and describe the different forms and complexities of nuclear matter that can exist in the universe, including those that are no longer found naturally.
- *Workforce Development for Teachers and Scientists* supports activities that engage students and professionals in science, technology, engineering, and mathematics (STEM) to help develop the skilled

scientific workforce needed for the Office of Science mission and the Nation.

- *Science Laboratories Infrastructure* focuses on ensuring the continued mission readiness of Office of Science laboratories and facilities to maintain the capability of those assets.
- *Safeguards and Security* supports the Department's research mission by ensuring appropriate levels of protection at the ten SC laboratories.
- *Science Program Direction* supports the Federal workforce that oversees SC investments in scientific research and national scientific user facilities.

The Office of Science is responsible for the oversight of ten DOE national laboratories: Ames National Laboratory, Argonne National Laboratory, Brookhaven National Laboratory, Fermi National Accelerator Laboratory, Lawrence Berkeley National Laboratory, Oak Ridge National Laboratory, Pacific Northwest National Laboratory, Princeton Plasma Physics Laboratory, SLAC National Accelerator Laboratory, and Thomas Jefferson National Accelerator Laboratory.

Alignment to Strategic Plan

Office of Science activities align to three objectives from the DOE Strategic Plan: extend our knowledge of the natural world, deliver new technologies to advance our mission, and sustain a world-leading technical workforce. For the Office of Science, the Strategic Plan identifies nine targeted outcomes for achieving these objectives.

Extend Our Knowledge of the Natural World

- Develop and explore a broad spectrum of new materials that have novel properties, such as catalysis, electrothermal behavior, radiation resistance, or strength, or otherwise contribute to the advancement of energy technologies by 2020.
- Explore the construction and use of x-ray free electron lasers and the next generation of synchrotron light sources.
- Determine the major sources of uncertainty in our understanding of the coupled climate system by 2015.
- Perform a series of experiments through 2020 in the intensity, energy, and cosmological frontiers to illuminate questions about the unification of the forces of nature, the structure of black holes, and the origins of the universe.
- Complete construction of nuclear physics facilities by the end of the decade at Jefferson Laboratory and Michigan State University to test quantum chromodynamics, the theory of nuclear forces, and produce exotic nuclei of relevance in astrophysical processes.

Deliver New Technologies to Advance Our Mission

- Apply systems biology approaches by 2015 to create viable biofuels processes and greatly increase the understanding of microbes in carbon-dioxide climate balance.
- Execute U.S. responsibilities for construction of the ITER project, consistent with sound project management principles.
- Continue to develop and deploy high-performance computing hardware and software systems through exascale platforms.

Sustain a World-Leading Technical Workforce

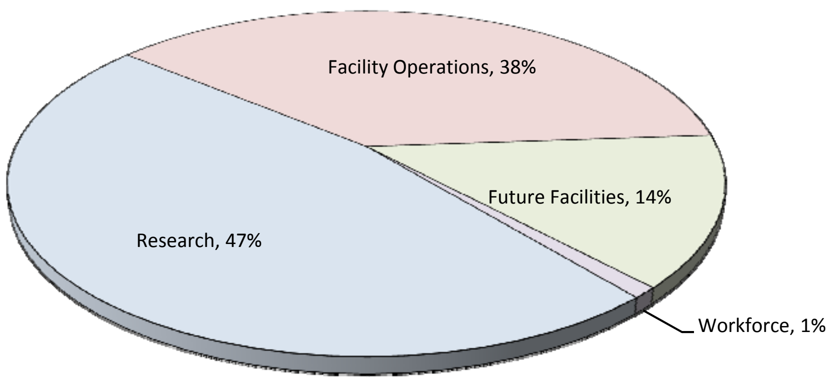
- Provide support by 2015 to students and educators in a manner designed to address skill gaps identified by senior Departmental leadership in the Department's scientific and technical workforce.

In support of its mission, Office of Science funding requests and performance expectations are focused on four areas:

- *Research*: Support fundamental research to increase our understanding of and enable predictive control of phenomena in the physical and biological sciences.
- *Facility Operations*: Maximize the reliability, dependability, and availability of the SC scientific user facilities.
- *Future Facilities*: Build future and upgrade existing facilities and experimental capabilities to ensure maximum benefit from the investments in SC scientific user facilities.
- *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/Program Alignment Summary

	Research	Facility Operations	Future Facilities	Workforce
Advanced Scientific Computing Research	49%	50%	0%	1%
Basic Energy Sciences	46%	44%	10%	0%
Biological and Environmental Research	65%	35%	0%	0%
Fusion Energy Sciences	45%	10%	45%	0%
High Energy Physics	55%	30%	15%	0%
Nuclear Physics	32%	56%	12%	0%
Workforce Development for Teachers and Scientists	0%	0%	0%	100%
Science Laboratories Infrastructure	0%	0%	100%	0%
Total, Office of Science	47%	38%	14%	1%



Explanation of Changes

The Office of Science FY 2013 request is for $4.99 billion, reflecting growth of $118 million or 2.4% relative to the FY 2012 appropriation. As part of the President's Plan for Science and Innovation, the Budget sustains the commitment to double the budgets of three key science agencies: the National Science Foundation, DOE's Office of Science, and the National Institutes of Standards and Technology laboratories.

Advanced Scientific Computing Research grows $14.7 million or 3.3%. The major changes are increased investments in data-intensive science.

Basic Energy Sciences increases $111 million or 6.6%. The major changes are the support for increases in scientific research related to clean energy including next generation materials and chemical processes and new collaborative efforts with the Office of Energy Efficiency and Renewable Energy to help translate scientific discoveries into new energy technologies.

Biological and Environmental Research includes an increase of $15.8 million or 2.6%. The major changes are investments in the development of synthetic biology tools and technologies, integrative analysis of experimental data sets, and climate observations in the Arctic.

Fusion Energy Sciences decreases $2.7 million or 0.7%. ITER funding grows by $45 million from $105 million to $150 million, while core research is reduced and operations at one research facility are terminated.

High Energy Physics decreases $14.3 million or 1.8%. The major changes in the program are the neutrino beamline upgrades at Fermilab, the start of design for two MIEs (Bella-II and the Large Synoptic Survey Telescope), and the completion of the ILC R&D program.

Nuclear Physics decreases $20.4 million or 3.7%. NP core research is reduced and operation time at NP national user facilities decreases. Construction of the 12 GeV CEBAF Upgrade project continues at a reduced level from FY 2012, and engineering and design effort for the Facility for Rare Isotope Beams is continued at the FY 2012 level.

High-Risk, High-Reward Research[a]

The need for fundamental scientific and technological breakthroughs to accomplish DOE mission goals requires that the Office of Science support high-risk, high-reward research ideas that challenge current thinking yet are scientifically sound. The Office of Science incorporates high-risk, high-reward basic research elements in all of its research portfolios; each Office of Science research program considers a significant proportion of its supported research as high-risk, high-reward. Because advancing the frontiers of science also depends on the continued availability of state-of-the-art scientific facilities, the Office of Science constructs and operates national scientific facilities and instruments that comprise the world's most sophisticated suite of research capabilities.

The Office of Science's basic research is integrated within program portfolios, projects, and individual awards; as such, it is not possible to quantitatively separate the funding contributions of particular experiments or theoretical studies that are high-risk, high-reward from other mission-driven research in a manner that is credible and auditable. The Office of Science focuses on cultivating and improving the program management practices and policies that foster support for this aspect of its research portfolio. Effective program management is critical to the support of high-risk, high-reward research. The Office of Science program managers are experts in their respective fields and communicate research priorities and interests to the scientific community; select proposal reviewers that are open to bold ideas; provide guidance to merit reviewers—including guidance on consideration of high-risk, high-reward research; and make recommendations on proposal selection, weighing inputs from merit review with programmatic relevance, potential impact, and overall portfolio balance. Committees of Visitors comprised of external experts review program portfolios triennially to assess, among other things, the balance and impact of the portfolios, including an assessment of high-risk, high-reward research.

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

Likewise, several mechanisms are used by the Office of Science to identify and develop "high-reward" research topics, including Federal advisory committees, program and topical workshops, interagency working groups, National Academies studies, and special Office of Science program solicitations. These activities have identified opportunities for new, compelling research. As examples, some of these opportunities are captured in the following reports: *Research at the Intersection of the Physical and Life Sciences*, by the National Research Council (2010); *New Worlds, New Horizons in Astronomy and Astrophysics,* the astronomy and astrophysics decadal survey (Astro2010 report), by the National Research Council; *Next-Generation Photon Sources for Grand Challenges in Science Energy*, by the Basic Energy Sciences Advisory Committee (BESAC) (2009); *Accelerators for Americas Future* workshop report (2009); *Advancing the Science of High Energy Density Laboratory Plasmas* by the Fusion Energy Sciences Advisory Committee (2009); *New Science for a Secure and Sustainable Energy Future*, by BESAC (2008); *Grand Challenges for Biological and Environmental Research: A Long-Term Vision*, by the Biological and Environmental Research Advisory Committee (2010); *U.S. Particle Physics: Scientific Opportunities, A Strategic Plan for the Next Ten Years*, by the High Energy Physics Advisory Panel; and *The Frontiers of Nuclear Science*, by the Nuclear Sciences Advisory Committee (2007).

Basic and Applied R&D Coordination

Coordination between the Department's basic research and applied technology programs is a high priority for the Secretary of Energy. The Department has a responsibility to coordinate its basic and applied research programs to effectively integrate R&D conducted by the science and technology communities (e.g., national laboratories, universities, and private companies) that support the DOE mission. The Department's efforts have focused on improving communication and collaboration between federal program managers and increasing opportunities for collaborative efforts among researchers targeted at the interface of scientific research and technology development to ultimately accelerate DOE mission and national goals.

Coordination between the basic and applied programs is enhanced through activities such as joint planning meetings and technical community workshops, joint annual contractor/awardee meetings, joint research solicitations, jointly-funded scientific facilities, and the program management activities of the DOE Small Business Innovation Research and Small Business Technology Transfer programs. Additionally, co-funding research activities and facilities at the DOE laboratories and funding mechanisms that encourage broad partnerships are also means by which the Department facilitates greater communication and research integration within the basic and applied research communities. Specific collaborative activities are highlighted in the "Basic and Applied R&D Coordination" sections of each individual Office of Science program budget justification narrative.

Scientific Workforce

The Office of Science and its predecessors have an over 50-year history in supporting the education and training of the skilled scientific workforce needed to tackle some of our Nation's most important societal challenges. Through its six research programs, the Office of Science supports the training of undergraduates, graduate students, and postdoctoral researchers through ongoing sponsored research awards at universities and the DOE national laboratories. Office of Science programs also support the development of individual research programs of outstanding scientists early in their careers to stimulate research careers in disciplines supported by the Office of Science.

Undergraduate activities include short intensive research training internships in specific areas such as geophysics, radiochemistry, nuclear science, computer science and computational-based sciences, plasma and fusion energy sciences, and climate science; and short courses in emerging areas in the physical sciences and engineering, including opportunities for groups underrepresented in the physical sciences. Graduate student level activities include support for short courses and lecture series as part of scientific professional society meetings; summer courses, lecture series, and experimental training courses in areas such as neutron and x-ray scattering, and high energy physics; and summer graduate research internships in targeted areas such as radiochemistry, accelerator physics, and nuclear physics. Opportunities directed towards K–12 educators, carried out primarily through the DOE national laboratories, include workshops, classroom presentations, and summer training programs that provide educators with content knowledge, materials, and activities related to the physical sciences and mathematics to use in the classroom.

In FY 2011, the Office of Science established a common set of guidelines for the reporting of education and workforce development programs by the six research programs to ensure consistent reporting and to ensure consistency with the definitions established by the National Science and Technology Council's Committee on STEM Education (CoSTEM), and the General Accountability Office study team conducting an inventory of all Federal STEM education programs. Significant changes in budget numbers from previous years reflect the consistent use of these guidelines and definitions, and the phasing out of programs terminated in FY 2010 and FY 2011. In December 2011, CoSTEM released its report on the *Federal Science, Technology, Engineering, and Mathematics (STEM) Education Portfolio.* Required by the 2010 reauthorization of the America COMPETES Act, the *Portfolio* report provides an inventory and analysis of the STEM education program across 13 Federal agencies, including DOE.

The Office of Science is committed to participating in the Department's pilot laboratory research internship project for the STEM education program authorized by section 101 of the America COMPETES Reauthorization Act of 2010.

Strategic Plan and Performance Measures

Strategic Goal: The Science and Engineering Enterprise—maintain a vibrant U.S. effort in science and engineering as a cornerstone of our economic prosperity, with clear leadership in strategic areas.

Objective: Extend Our Knowledge of the Natural World

Targeted Outcome: Develop and explore a broad spectrum of new materials that have novel properties, such as catalysis, electrothermal behavior, radiation resistance, or strength, or otherwise contribute to the advancement of energy technologies by 2020.

Targeted Outcome: Explore the construction and use of X-ray free electron lasers and the next generation of synchrotron light sources.

Annual Measure: Maintain specific characteristics of a user facility's beam needed to create data for research experiments. *(Measure applies to both of the prior targeted outcomes.)*

	Target	Actual/Met or Not Met
FY 2013	Light source facilities image resolution of <100 nm for hard x-ray and <18 nm for soft x-ray; X-ray FEL facility with x-ray pulse duration <70 femtoseconds with intensity of >1 trillion (10^{12}) photons per pulse	N/A
FY 2012	Light source facilities image resolution of <100 nm for hard x-ray and <18 nm for soft x-ray; X-ray FEL facility with x-ray pulse duration <70 femtoseconds with intensity of >1 trillion (10^{12}) photons per pulse	N/A
FY 2011	N/A	N/A

Analysis: New instruments lie at the heart of discovery. These advanced instruments image systems that move in space and time and change in energy with the correct resolution for each of these three dimensions. The ability to image structure and function will inform and direct our efforts to control molecules and materials. Devices to direct matter at the levels of electrons, atoms, and molecules will naturally emerge from new generations of facilities. The importance of x-ray free electron laser and the light source facilities for seeing more deeply into nature and discovering a broad spectrum of new materials is specified in two Basic Energy Sciences Advisory Committee reports, *Directing Matter and Energy: Five Challenges for Science and the Imagination* and *Next-Generation Photon Sources for Grand Challenges in Science and Energy*.

Targeted Outcome: Determine the major sources of uncertainty in our understanding of the coupled climate system by 2015.

Annual Measure: Develop a coupled climate model with fully interactive carbon and sulfur cycles, as well as dynamic vegetation to enable simulations of aerosol effects, carbon chemistry, and carbon sequestration by the land surface and oceans and the interactions between the carbon cycle and climate.

	Target	Actual/Met or Not Met
FY 2013	Use global models to estimate the most sensitive elements of cloud and terrestrial carbon for tropics, mid-latitudes, and polar regions.	N/A
FY 2012	Demonstrate coupled climate models at 20 km resolution	N/A
FY 2011	Earth system model to be used in generating scenarios for the IPCC Fifth Assessment Report and provide integrated aerosol sub-model that includes direct and indirect forcing.	Met

Analysis: Deliver improved scientific data and models (with quantified uncertainties) about the potential response of the earth-atmosphere system to more accurately predict the Earth's future climate are essential to plan for future energy needs, water resources, and land use.

Targeted Outcome: Perform a series of experiments through 2020 in the intensity, energy, and cosmological frontiers to illuminate questions about the unification of the forces of nature, the structure of black holes, and the origins of the universe.

Annual Measure: Within 20% deliver a total number of protons to the NuMI neutrino production target for the MINOS and MINERvA experiments.

	Target	Actual/Met or Not Met
FY 2013	Baseline is 2.0×10^{20} (within 20% is 1.6×10^{20})	N/A
FY 2012	Baseline is 1.5×10^{20} (within 20% is 1.2×10^{20})	N/A
FY 2011	Baseline is 2.7×10^{20} (within 20% is 2.2×10^{20})	Met

Analysis: While neutrinos rarely interact with other matter, the number of neutrinos produced by a beam is directly related to the number of protons that strike the neutrino production target. Measuring the number of protons on target should accurately predict the number of neutrinos produced and inform determination of the statistical precision of the experimental measurements.

Targeted Outcome: Complete the construction of nuclear physics facilities by the end of the decade at Jefferson Laboratory and Michigan State University to test quantum chromodynamics, the theory of nuclear forces, and produce exotic nuclei of relevance in astrophysical processes.

Annual Measure: Achieve within 10% for both the cost-weighted mean percentage variance from established cost and schedule baselines for major construction, upgrade, or equipment procurement projects.

	Target	Actual/Met or Not Met
FY 2013	<10%	N/A
FY 2012	<10%	N/A
FY 2011	<10%	Met

Analysis: Project cost or schedule changes for the baselined 12 GeV project at Jefferson Laboratory, as a result of the FY 2012 appropriation, have not yet been evaluated and reviewed. While the Facility for Rare Isotope Beams project at Michigan State University is not yet baselined, project cost or schedule changes as a result of the FY 2012 appropriation have not yet been evaluated and reviewed.

Objective: Deliver New Technologies to Advance Our Mission

Targeted Outcome: Apply systems biology approaches by 2015 to create viable biofuels processes and greatly increase the understanding of microbes in carbon-dioxide climate balance.

Annual Measure: Increase by at least 50% the number of high quality (less than one error in 10,000) bases of DNA from microbial and model organism genomes sequenced the previous year.

	Target	Actual/Met or Not Met
FY 2013	To be determined based on FY 2012 results	N/A
FY 2012	Sequence 44,855 billion base pairs	N/A
FY 2011	Sequence 1,100 billion base pairs[a]	Met

Analysis: Provides the fundamental scientific understanding of plants and microbes necessary to develop new robust and transformational basic research strategies for producing biofuels, cleaning up waste, and sequestering carbon.

Targeted Outcome: Execute U.S. responsibilities for construction of the ITER project, consistent with sound project management principles.

Annual Measure: Cost-weighted mean percent variance from established cost and schedule baselines for major construction, upgrade, or equipment procurement projects kept to less than 10%.

	Target	Actual/Met or Not Met
FY 2013	<10%	N/A
FY 2012	<10%	N/A
FY 2011	<10%[b]	Met

Analysis: Adhering to the cost and schedule baselines for a complex, large scale, science project while maintaining a balanced research portfolio will help meet the scientific requirements for the project and promote sound stewardship of taxpayer funds.

Targeted Outcome: Continue to develop and deploy high-performance computing hardware and software systems through exascale platforms.

Annual Measure: Demonstrate progress toward delivering exascale science for advancing fundamental

[a] The target for this annual measure included a base pair per dollar component. This component was achieved.
[b] The FY 2011 project measure applies to Fusion Energy Sciences' National Spherical Tokamak Experiment Upgrade, not to ITER, which has not yet been baselined.

research to understand, predict, and engineer complex systems of interest to the Department.

	Target	Actual/Met or Not Met
FY 2013	Accept and put into service 10 petaflop upgrades at Argonne and Oak Ridge Leadership Computing Facilities to support scientific discovery.	N/A
FY 2012	Develop an exascale plan that is coordinated with NNSA and socialized with the community and policy makers.	N/A
FY 2011	N/A	N/A

Analysis: Advances in high performance computing underpin U.S. leadership in disciplines across DOE missions. The ability to understand physical and engineered systems at unprecedented levels of fidelity along with detailed understanding of the uncertainty will result from future computers. The potential of these computers to enhance DOE's ability to meet its missions across the Department is detailed in the Advanced Scientific Computing Advisory Committee report: *Opportunities and Challenges of Exascale Computing*.

Objective: Sustain a World-Leading Technical Workforce

Targeted Outcome: Provide support by 2015 to graduate students in a manner designed to address skill gaps identified by senior Departmental leadership in the Department's scientific and technical workforce.

Annual Measure: The percentage of SULI students who report in their exit survey they have increased their preparedness for a STEM career as a result of the program.

	Target	Actual/Met or Not Met
FY 2013	≥ 90%	N/A
FY 2012	N/A	N/A
FY 2011	N/A	N/A

Analysis: Provide participants a pathway to STEM careers in scientific disciplines relevant to DOE's mission in energy, environment, and national security, including careers at the Department and its national laboratories.

<u>Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR)</u>

(Dollars in Thousands)

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Advanced Scientific Computing Research	0	12,563	13,438
Basic Energy Sciences	0	42,699	48,898
Biological and Environmental Research	0	17,055	18,759
Fusion Energy Sciences	0	8,167	6,881
High Energy Physics	0	20,040	20,590
Nuclear Physics	0	12,889	12,970
SBIR/STTR (SC funding)	108,418	0	0
Subtotal, SBIR/STTR	108,418	113,413	121,536
SBIR/STTR (funds transferred from other DOE programs)	54,618	N/A	N/A
Total, SBIR/STTR	163,036	N/A	N/A

SBIR and STTR funding is transferred from research programs across the Department to the Small Business Innovation Research/Technology Transfer programs in the Office of Science for distribution to award recipients. All contributing programs participate in the selection of awards. In FY 2011, 2.8% of funding subject to the SBIR/STTR mandate was transferred (2.5% for SBIR and 0.3% for STTR). In FY 2012, the rate increases to 2.95% (2.6% for SBIR and 0.35% for STTR) and increases to 3.05% in FY 2013 (2.7% for SBIR and 0.35% for STTR). FY 2012 funding will be transferred during FY 2012, but no transfer is reflected in this budget document.

Office of Science
Funding by Site by Program

	(dollars in thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Ames Laboratory			
Advanced Scientific Computing Research	470	0	0
Basic Energy Sciences	23,647	18,919	21,694
Biological and Environmental Research	894	500	500
Workforce Development for Teachers and Scientists	146	0	0
Safeguards and Security	1,007	993	910
Total, Ames Laboratory	26,164	20,412	23,104
Ames Site Office			
Program Direction	546	545	561
Argonne National Laboratory			
Advanced Scientific Computing Research	79,453	75,832	68,654
Basic Energy Sciences	226,320	213,744	228,429
Biological and Environmental Research	36,769	22,151	28,457
Fusion Energy Sciences	49	40	40
High Energy Physics	19,836	17,868	15,934
Nuclear Physics	29,619	27,235	26,851
Workforce Development for Teachers and Scientists	1,428	0	0
Science Laboratories Infrastructure	14,970	40,000	32,030
Safeguards and Security	9,211	8,858	8,601
Total, Argonne National Laboratory	417,655	405,728	408,996
Argonne Site Office			
Program Direction	3,608	3,974	4,433
Berkeley Site Office			
Program Direction	4,345	3,954	4,072

	(dollars in thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Brookhaven National Laboratory			
Advanced Scientific Computing Research	760	300	0
Basic Energy Sciences	257,077	263,388	201,941
Biological and Environmental Research	20,827	16,806	18,911
High Energy Physics	56,799	48,043	45,284
Nuclear Physics	185,163	180,313	178,197
Workforce Development for Teachers and Scientists	2,182	202	0
Science Laboratories Infrastructure	14,970	15,500	14,530
Safeguards and Security	12,228	12,582	12,312
Total, Brookhaven National Laboratory	550,006	537,134	471,175
Brookhaven Site Office			
Program Direction	4,876	4,870	5,027
Chicago Office			
Advanced Scientific Computing Research	53,886	23,050	13,430
Basic Energy Sciences	277,754	306,260	352,209
Biological and Environmental Research	155,312	158,608	130,891
Fusion Energy Sciences	155,249	137,430	106,946
High Energy Physics	132,380	138,069	127,013
Nuclear Physics	81,944	91,721	85,985
Workforce Development for Teachers and Scientists	199	0	0
Science Laboratories Infrastructure	1,382	1,385	1,385
Safeguards and Security	92	133	77
Program Direction	45,152	28,896	31,636
SBIR/STTR	163,036	0	0
Total, Chicago Office	1,066,386	885,552	849,572

	(dollars in thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Fermi National Accelerator Laboratory			
Advanced Scientific Computing Research	767	75	0
Basic Energy Sciences	86	0	0
High Energy Physics	409,914	381,857	359,127
Nuclear Physics	976	0	612
Workforce Development for Teachers and Scientists	46	0	0
Science Laboratories Infrastructure	0	0	2,500
Safeguards and Security	3,666	3,533	3,413
Total, Fermi National Accelerator Laboratory	415,455	385,465	365,652
Fermi Site Office			
Program Direction	2,148	2,243	2,310
Golden Field Office			
Workforce Development for Teachers and Scientists	476	0	0
Idaho National Laboratory			
Basic Energy Sciences	2,232	1,700	1,700
Biological and Environmental Research	1,404	1,190	0
Fusion Energy Sciences	2,372	2,222	2,173
Workforce Development for Teachers and Scientists	251	0	0
Total, Idaho National Laboratory	6,259	5,112	3,873

	(dollars in thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Lawrence Berkeley National Laboratory			
Advanced Scientific Computing Research	114,009	106,463	105,380
Basic Energy Sciences	169,862	149,992	160,492
Biological and Environmental Research	138,712	130,167	133,151
Fusion Energy Sciences	5,520	4,584	0
High Energy Physics	54,012	47,153	45,419
Nuclear Physics	24,110	23,415	17,946
Workforce Development for Teachers and Scientists	1,149	0	0
Science Laboratories Infrastructure	20,063	12,975	0
Safeguards and Security	6,141	5,127	4,879
Total, Lawrence Berkeley National Laboratory	533,578	479,876	467,267
Lawrence Livermore National Laboratory			
Advanced Scientific Computing Research	15,449	10,178	4,425
Basic Energy Sciences	4,677	1,803	3,251
Biological and Environmental Research	17,671	13,390	14,352
Fusion Energy Sciences	13,601	11,129	5,705
High Energy Physics	2,029	1,731	550
Nuclear Physics	3,392	822	1,164
Workforce Development for Teachers and Scientists	205	0	0
Total, Lawrence Livermore National Laboratory	57,024	39,053	29,447
Los Alamos National Laboratory			
Advanced Scientific Computing Research	7,056	5,770	2,950
Basic Energy Sciences	41,795	38,002	38,952
Biological and Environmental Research	12,677	20,606	23,712
Fusion Energy Sciences	5,182	3,427	2,386
High Energy Physics	1,533	1,380	1,237
Nuclear Physics	11,616	9,548	8,584
Workforce Development for Teachers and Scientists	31	0	0
Total, Los Alamos National Laboratory	79,890	78,733	77,821

	(dollars in thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
NNSA Albuquerque Complex			
Advanced Scientific Computing Research	3,000	0	0
National Energy Technology Laboratory			
Basic Energy Sciences	5,000	0	0
Workforce Development for Teachers and Scientists	445	120	0
Total, National Energy Technology Laboratory	5,445	120	0
National Renewable Energy Laboratory			
Advanced Scientific Computing Research	472	186	186
Basic Energy Sciences	12,978	11,888	11,888
Biological and Environmental Research	1,586	1,168	900
Workforce Development for Teachers and Scientists	64	75	0
Total, National Renewable Energy Laboratory	15,100	13,317	12,974
Nevada Site Office			
Basic Energy Sciences	244	244	244
New Brunswick Laboratory			
Program Direction	6,132	5,940	6,145
Oak Ridge Institute for Science and Education			
Advanced Scientific Computing Research	1,500	1,000	1,000
Basic Energy Sciences	4,120	1,600	1,600
Biological and Environmental Research	5,386	2,942	3,378
Fusion Energy Sciences	960	1,100	650
High Energy Physics	1,380	0	0
Nuclear Physics	1,304	910	732
Workforce Development for Teachers and Scientists	13,977	5,295	0
Safeguards and Security	1,671	1,645	1,572
Program Direction	84	0	0
Total, Oak Ridge Institute for Science and Education	30,382	14,492	8,932

	(dollars in thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Oak Ridge National Laboratory			
Advanced Scientific Computing Research	110,007	100,240	84,389
Basic Energy Sciences	335,033	316,221	315,047
Biological and Environmental Research	79,385	71,235	72,584
Fusion Energy Sciences	101,251	119,715	160,633
High Energy Physics	50	44	50
Nuclear Physics	37,283	22,548	19,923
Safeguards and Security	9,183	9,016	8,668
Total, Oak Ridge National Laboratory	672,192	639,019	661,294
Oak Ridge National Laboratory Site Office			
Program Direction	4,355	3,998	5,949
Oak Ridge Office			
Biological and Environmental Research	0	1,000	0
Science Laboratories Infrastructure	5,250	5,493	5,934
Safeguards and Security	20,011	18,000	17,864
Program Direction	38,478	34,043	36,071
Total, Oak Ridge Office	63,739	58,536	59,869
Office of Scientific and Technical Information			
Advanced Scientific Computing Research	211	125	125
Basic Energy Sciences	435	125	125
Biological and Environmental Research	542	192	267
Fusion Energy Sciences	252	125	125
High Energy Physics	125	125	124
Nuclear Physics	160	275	125
Workforce Development for Teachers and Scientists	100	0	0
Safeguards and Security	504	497	445
Program Direction	11,250	8,417	8,900
Total, Office of Scientific and Technical Information	13,579	9,881	10,236

	(dollars in thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Pacific Northwest National Laboratory			
Advanced Scientific Computing Research	7,099	4,455	1,600
Basic Energy Sciences	28,028	21,811	23,112
Biological and Environmental Research	114,740	119,218	103,999
Fusion Energy Sciences	1,163	1,163	1,163
High Energy Physics	1,005	964	6,408
Nuclear Physics	204	100	83
Workforce Development for Teachers and Scientists	924	115	0
Safeguards and Security	11,515	11,317	11,030
Total, Pacific Northwest National Laboratory	164,678	159,143	147,395
Pacific Northwest Site Office			
Program Direction	5,321	5,170	5,330
Princeton Plasma Physics Laboratory			
Advanced Scientific Computing Research	613	0	0
Fusion Energy Sciences	76,992	71,354	59,482
High Energy Physics	240	0	230
Workforce Development for Teachers and Scientists	127	0	0
Safeguards and Security	2,397	2,232	2,128
Total, Princeton Plasma Physics Laboratory	80,369	73,586	61,840
Princeton Site Office			
Program Direction	1,661	1,763	1,816
Sandia National Laboratories			
Advanced Scientific Computing Research	14,125	11,712	3,549
Basic Energy Sciences	46,993	38,507	39,757
Biological and Environmental Research	1,922	5,976	9,215
Fusion Energy Sciences	3,406	2,913	2,447
Workforce Development for Teachers and Scientists	32	0	0
Total, Sandia National Laboratories	66,478	59,108	54,968

	(dollars in thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Savannah River National Laboratory			
Basic Energy Sciences	535	530	530
Biological and Environmental Research	427	40	368
Total, Savannah River National Laboratory	962	570	898
SLAC National Accelerator Laboratory			
Advanced Scientific Computing Research	300	100	0
Basic Energy Sciences	189,655	206,261	254,761
Biological and Environmental Research	4,900	4,375	4,375
High Energy Physics	91,367	83,921	82,491
Workforce Development for Teachers and Scientists	230	0	0
Science Laboratories Infrastructure	40,694	24,110	58,011
Safeguards and Security	3,596	2,676	2,595
Total, SLAC National Accelerator Laboratory	330,742	321,443	402,233
SLAC Site Office			
Program Direction	2,855	2,565	2,641
Thomas Jefferson National Accelerator Facility			
Basic Energy Sciences	3,200	1,500	1,500
Biological and Environmental Research	600	600	600
High Energy Physics	2,012	2,795	10
Nuclear Physics	130,784	138,776	131,398
Workforce Development for Teachers and Scientists	233	119	0
Science Laboratories Infrastructure	28,419	12,337	2,500
Safeguards and Security	1,668	1,446	1,386
Total, Thomas Jefferson National Accelerator Facility	166,916	157,573	137,394
Thomas Jefferson Site Office			
Program Direction	2,147	1,911	1,969

	(dollars in thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Washington Headquarters			
Advanced Scientific Computing Research	1,140	101,382	169,905
Basic Energy Sciences	8,840	95,598	142,360
Biological and Environmental Research	1,492	39,393	79,687
Fusion Energy Sciences	1,260	45,794	56,574
High Energy Physics	2,657	66,910	92,644
Nuclear Physics	21,129	51,724	55,338
Workforce Development for Teachers and Scientists	355	12,574	14,500
Science Laboratories Infrastructure	0	0	900
Safeguards and Security	896	2,518	8,120
Program Direction	69,562	76,711	85,691
Total, Washington Headquarters	107,331	492,604	705,719
Waste Isolation Pilot Plant			
High Energy Physics	239	0	0
Total, Science	4,912,283	4,873,634	5,001,156

Advanced Scientific Computing Research
Funding Profile by Subprogram and Activity

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Mathematical, Computational, and Computer Sciences Research			
Applied Mathematics	45,604	45,604	49,500
Computer Science	47,301	47,400	54,580
Computational Partnerships	52,813	44,250	56,776
Next Generation Networking for Science	12,313	12,751	16,194
SBIR/STTR	0	4,560	5,570
Total, Mathematical, Computational, and Computer Sciences Research	158,031	154,565	182,620
High Performance Computing and Network Facilities			
High Performance Production Computing	59,514	57,800	65,605
Leadership Computing Facilities	158,020	156,000	145,000
Research and Evaluation Prototypes	4,301	30,000	22,500
High Performance Network Facilities and Testbeds	30,451	34,500	32,000
SBIR/STTR	0	8,003	7,868
Total, High Performance Computing and Network Facilities	252,286	286,303	272,973
Total, Advanced Scientific Computing Research	410,317[a]	440,868[b]	455,593

[a] Total is reduced by $11,680,000: $10,428,000 of which was transferred to the Small Business Innovation Research (SBIR) program and $1,252,000 of which was transferred to the Small Business Technology Transfer (STTR) program.
[b] The FY 2012 appropriation is reduced by $1,132,000 for the Advanced Scientific Computing Research share of the DOE-wide $73,300,000 rescission for contractor pay freeze savings. The FY 2013 budget request reflects the FY 2013 impact of the contractor pay freeze.

Public Law Authorizations

Public Law 95-91, "Department of Energy Organization Act", 1977
Public Law 108-423, "Department of Energy High-End Computing Revitalization Act of 2004"
Public Law 109-58, "Energy Policy Act of 2005"
Public Law 110-69, "America COMPETES Act of 2007"

Program Overview and Benefits

The Advanced Scientific Computing Research (ASCR) program's mission is to advance applied mathematics and computer science; deliver, in partnership with disciplinary science, the most advanced computational scientific applications; advance computing and networking capabilities; and develop, in partnership with U.S. industry, future generations of computing hardware and tools for science. A particular challenge of this program is fulfilling the science potential of emerging computing systems and other novel computing architectures, which will require numerous and significant modifications to today's tools and techniques to deliver on the promise of exascale science.

ASCR efforts support the Department's goal to maintain a vibrant U.S. effort in science and engineering as a cornerstone of our economic prosperity with clear leadership in strategic areas. As a direct result of DOE investments over the past decade, the U.S. currently holds clear leadership in high performance computational science and engineering. To continue U.S.

leadership in this area, ASCR must address two significant challenges: advancing the Department's science and engineering missions by effectively utilizing our existing hardware and software, and supporting research to extend these capabilities and take on even more complex challenges. Through our regular requirements gathering efforts, it is clear that Department of Energy (DOE) simulation and data analysis needs exceed petascale capabilities and are driving us toward exascale computing. However, computer industry roadmaps reveal a period of significant change and several critical technology challenges on the path to exascale that will impact both data-intensive and compute-intensive applications. These changes will require a fundamental shift in both hardware and software development to deliver increased application performance while limiting growth in system power requirements. In addition, new algorithms will be required that optimize management of data movement.

According to the National Research Council of the National Academies' 2011 report *The Future of Computing Performance, Game Over or Next Level?* [a], "Virtually every sector of society—manufacturing, financial services, education, science, government, the military, entertainment, and so on—has become dependent on continued growth in computing performance to drive new efficiencies and innovation." The report found "The growth in the performance of computing systems . . . will become limited by power consumption within a decade" and "There are opportunities for major changes in system architectures, and extensive investment in whole-system research is needed to lay the foundation of the computing environment for the next generation."

Informed by analyses of future computational needs including this report, ASCR is supporting long-term, coordinated investments across the ASCR research portfolio including Research and Evaluation Prototypes investments fund breakthrough technologies that minimize the technical risk associated with the next generation of supercomputing hardware.

ASCR is also supporting new and redirected efforts in Applied Math and Computer Science to develop new tools and techniques that address the challenges of current and future data-intensive science and the coming generation of high performance computing (HPC) designs. Co-design partnerships between applications and vendors are supported to create feedback loops in the design of the emerging HPC architectures to ensure science and engineering applications are ready and able to use commercial offerings that have been made more competitive and more resilient through input from their most challenging users. To achieve all of this, ASCR is working closely with the National Nuclear Security Administration (NNSA), which is addressing these same challenges for the Department's national security applications. In April 2011, a Memorandum of Understanding was signed between the Office of Science (SC) and the NNSA's Office of Defense Programs regarding collaboration and coordination of exascale activities across the two organizations. The ten year goal for these efforts is the delivery of energy-efficient exascale computing systems (computing systems capable of 10^{18} (a quintillion) floating point operations per second—1,000 times current capabilities—while using only twice as much electricity) for the advancement of DOE science and engineering. However, this effort will also deliver, along the path to the exascale goal, solutions to the software and hardware challenges of future computing at all scales. In this way, DOE's investment in exascale research will impact the entire computing and scientific research enterprise in the United States.

Today, ASCR is actively engaged in sharing our expertise to further broaden the benefits of our past and current investments. The National Energy Research Scientific Computing Center (NERSC) is available for scientists supported by SC programs for mission-related research, ASCR Leadership Computing Facilities (LCFs) are available to all researchers—including industry and academia—for scientific discovery and to address critical engineering challenges. These partnerships, and planned exascale partnerships, benefit many sectors of the economy from high-tech industry and academic research to software development and engineering. ASCR's support of researchers and students (the next generation of researchers) is a benefit to the national research and development workforce.

ASCR has long-established expertise in delivering forefront computational capabilities in a way that involves and prepares the research communities for advancing science. ASCR-supported high-performance computing systems are the culmination of a decade-long effort to build computing architectures with unprecedented speed and capability. At the same time,

[a] http://www.nap.edu/openbook.php?record_id=12980

ASCR-supported development of new mathematical theories and algorithms increases the speed at which difficult scientific problems can be solved as much or more than the increased computational power of supercomputers. Finally, to ensure that the Department's science and engineering communities were ready to use Leadership Computing Facilities, ASCR fostered collaborations encompassing applied mathematics, computer science, physics, biology, chemistry, and others.

These investments extend our knowledge of the natural world and have direct benefit to science and society at large. For example, Scientific Discovery through Advanced Computing (SciDAC) efforts include:

- Computational chemistry and simulation of nanomaterials relevant to energy applications in partnership with the Basic Energy Sciences program.
- Next generation integrated earth system models with uncertainty quantification to dramatically improve our ability to characterize variables in global climate and quantify the impact of energy production and use on the environment and human health in partnership with the Biological and Environmental Research program.
- Computer modeling of nuclear structure with relevance for science, nuclear energy, and nuclear weapons in partnership with the Nuclear Physics program and the National Nuclear Security Administration.

ASCR is working to broaden the impact of our research efforts through outreach, workshops and program manager interactions with the DOE applied programs. For example, ASCR is taking a new approach to our small business investments to help commercialize our software and middleware. The Leadership Computing Facilities also regularly transfer ASCR developed tools and techniques to academic and industrial users through user support. ASCR-supported researchers are also focusing on the mathematical and computational challenges of the electricity grid and nuclear reactor modeling. ASCR research in the mathematics of complex natural and engineered systems and uncertainty quantification is relevant to DOE efforts in carbon sequestration, wind energy, next generation nuclear reactors, Smart Grid, cyber security, and fuels from sunlight.

In many areas of research, computation is an essential tool for discovery. SciDAC accelerates scientific progress by breaking down the barriers between disciplines and fostering more dynamic partnerships between applications (materials, chemistry, fusion, bioenergy, climate, accelerator R&D, nuclear structure, etc.) and computer scientists and mathematicians. These partnerships have been spectacularly successful, with documented improvements in code performance in excess of 10,000 percent.

Advances in mathematics and computing are the foundation for models, simulations, and data analysis, which permit scientists and engineers to gain new insights into problems ranging from bioenergy and climate change to optimizing complex engineered systems such as nuclear reactors and the electricity grid. ASCR and its predecessor programs have led these advances for more than thirty years by supporting the best applied math and computer science research, delivering world-class scientific simulation facilities, and working with discipline scientists to deliver exceptional science.

Science is increasingly collaborative, requiring researchers not only to communicate with each other, but also to move, share and exchange large scientific data sets. Scientists also need to run complex calculations and experiments in locations remote from where the original data is collected or generated. ASCR has played a leading role in driving development of the high-fidelity, high-bandwidth networks connecting researchers to each other and their data.

Looking forward, ASCR will continue to be guided by science needs and engineering challenges as it develops tools, techniques, computers and networks at the leading edge of technology. ASCR has the experience and know-how to deliver exascale computing. Like the path to petascale computing, the path to exascale is driven by the requirements of applications that are critical to DOE and the Nation. In addition, this path will result in not only exascale computing capability but also new tools and techniques for data-intensive science, and affordable, energy efficient petascale systems to drive scientific and engineering discovery across the country. With this integrated approach, ASCR will continue to deliver scientific insight to address national problems in energy and the environment.

Basic and Applied R&D Coordination

Coordination across disciplines and programs is an ASCR cornerstone. Partnerships within SC are mature and continue to advance the use of high performance computing and scientific networks for science. In addition, ASCR continues to have a strong partnership with the National Nuclear Security Administration in areas of mutual interest including exascale research, workforce development, and best practices for management of high performance computing facilities. In April 2011, ASCR and NNSA strengthened this partnership by signing a Memorandum of Understanding for collaboration and coordination of exascale research within the Department. Through the National Information Technology Research and Development (NITRD) subcommittee, an interagency networking and information technology R&D collaboration effort, ASCR also coordinates with similar programs across the Federal Government and directly partners with the Department of Defense on developing High Productivity Computing Systems and software.

Key areas of mutual interest with the DOE technology programs continue to be applied mathematics for the optimization of complex systems, control theory, and risk assessment. A March 2009 workshop, in partnership with the Office of Electricity Delivery and Energy Reliability (OE), focused on the challenges of grid modernization efforts. This workshop was part of a series of workshops on basic research needs in applied R&D areas. Other workshops have covered advanced nuclear energy systems (with the Office of Nuclear Energy), subsurface science (with the Offices of Environmental Management and Fossil Energy), cyber security (with OE), alternative and renewable energy (with the Office of Energy Efficiency and Renewable Energy), and the scientific challenges of exascale computing for national security (with the National Nuclear Security Administration). These workshops facilitate a dialogue between the ASCR research community and a specific applied R&D community to identify opportunities for new research. This research becomes part of the ASCR program through investigator-driven research proposals and is coordinated with the applied efforts through program manager interactions and joint principal investigator meetings.

ASCR and OE significantly increased interactions during FY 2011 through the Grid Tech Team meetings and other activities. ASCR and OE program managers meet weekly to enhance communication and collaboration on the electric grid. In addition, ASCR researchers had a significant role in the OE-sponsored workshop on Computational Needs for the Next Generation Electric Grid held at Cornell University in April 2011. OE was represented at an ASCR-sponsored workshop for Mathematics for the Analysis, Simulation, and Optimization of Complex Systems in September 2011 and the ASCR Applied Mathematics program meeting in October 2011.

Program Accomplishments and Milestones

Minimizing Data Movement to Speed Computations. On modern, high-performance computers, data computations can occur 100 times faster than data movement to the processor. ASCR researchers have developed a new approach (message driven computation) to take advantage of hardware innovations by arranging algorithms to minimize data movement and speed computation up to 30-fold[a].

Novel Designs Save Energy, Accelerate Networks. ASCR computer scientists, focusing on the energy demands of data movement, are using simulators to explore novel memory systems and interconnects that have the potential to provide power savings of up to $13 billion annually, while sharply reducing network latency—making data flow faster. Their initial studies show 63–98% reduction in energy usage and a factor of 10 improvement in effective network bandwidth. These efforts will inform the new vendor partnerships to develop critical technologies that realize those potentials.

High Performance Computations Save DOE Time and Money. A SciDAC partnership with NNSA focused on nuclear structure provided a quantitative description of neutron-tritium scattering that was precise enough for designers at the National Ignition Facility (NIF) to make critical fuel assembly decisions that could not have been achieved using physical testing within the NIF cost and schedule baselines.

Crash Site Investigation for Networks: The complex structure of modern networks means that faults on any single link in the network can impact multiple users across the network. These faults can cause data traffic to slow-down in other parts of the network, misleading operators as they attempt to find the faulty link. DOE

[a] http://lightwave.ee.columbia.edu/files/Bergman2011.pdf

researchers have developed analysis algorithms that can quickly sort through measurement data to separate real faults from these secondary effects. Once fully deployed, network operators will be able to track down infrastructure faults more quickly and efficiently.

Simulations Explain LED-based Light Bulb Performance Issues. Light-emitting diodes (LEDs) hold enormous potential as energy-efficient, nontoxic, long-lasting replacements for incandescent bulbs and compact florescent lights. However, LED lighting is expensive because of a dramatic drop in efficiency, known as droop, at the intensities needed for full room illumination. A simulation using NERSC computers allowed researchers to discover the dominant contributors to LED droop, as well as hints to how it might be overcome leading to better LED-based light bulbs.

Understanding the Complex Behavior of Oil in the Gulf of Mexico. Researchers running simulations at the Argonne Leadership Computing Facility were able to do the first ever simulations of a buoyant oil plume in a stratified and rotating ocean environment. These results helped in understanding the behavior of the Deepwater Horizon oil spill in the Gulf of Mexico and informed planning for future emergencies.

Partnering with Industry to Save Energy and Improve Competitiveness. GE Global Research used the Oak Ridge Leadership Computing Facility to study, for the first time, unsteady airflows in the blade rows of turbo machines used in modern jet engines. Simulations of unsteady airflow are orders of magnitude more complex than simulations of steady flows and beyond the capabilities of GE's in-house systems. The insights gained will impact aircraft engine design and could lead to substantial reductions in energy consumption and substantial cost savings. GE Global Research recently purchased a substantial upgrade to its in-house computing capabilities to continue this work, based largely on the results of this project.

First Nation-wide 100 gigabit per second Network. In September 2011, ESnet turned on to the world's first nation-wide 100 gigabit per second optical network testbed. The demonstration network is designed in part to help accelerate the commercial deployment of emerging networking technologies, and ensure America's global leadership in the development of ultra-high broadband networking, by demonstrating the technology and providing a research testbed at scale. The network uses special optical equipment to transmit more than ten times more data via already existing fiber optic cable and will immediately provide greater connectivity among ASCR supercomputing centers to meet the ever growing requirements of scientific research and collaboration.

Milestone	Date
Develop joint plan for exascale R&D with NNSA.	Q2 FY 2012
Award at least two new SciDAC science application partnerships.	Q4 FY 2012

Explanation of Changes

The market for computer hardware is driven by the demands of consumer electronics, commercial data farms, and business computing. The demands of DOE science and engineering applications and data-intensive science are significantly different from these high-volume customers yet progress is dependent on the availability of usable commercial hardware. The challenges of developing high performance scientific computing systems on the path to exascale and the demands of some critical DOE facilities and applications require us to look ahead and make long-term, coordinated investments across the ASCR research portfolio. The FY 2013 budget increases investments across the ASCR research portfolio with a focus on the linked challenges of data-intensive science and exascale computing. These investments will span the entire enterprise from hardware to applications and will advance critical technologies, mathematical methods, software, tools, middleware, and science applications. In FY 2013, exascale relevant investments total $68,500,000 and data-intensive science investments total $21,000,000.

New research efforts will be supported across the ASCR portfolio with a focus on addressing the challenges of data-intensive science and the massive data expected from DOE mission research, including research at current and planned scientific user facilities. There are two broad categories in which DOE's missions lead to unique data-centric computing challenges that span the portfolios of ASCR and the other research programs:

- DOE researchers routinely compute detailed models of time dependent, three dimensional systems on some of the world's largest computers. These simulations generate enormous data sets that are difficult to extract and archive, let alone analyze.

More comprehensive analysis of the data will help in the discovery and identification of unanticipated phenomena, and also help expose shortcomings in the simulation methodologies and software.

- DOE manages the Nation's most advanced experimental resources, and these facilities generate tremendous amounts of data. Data sets generated at DOE's scientific facilities today significantly outstrip the current analysis capability. Basic research in Applied Mathematics and Computer Science, coupled to expertise from the facilities, is required to realize the significant potential that exists in DOE facilities data.

Investments in Research and Evaluation Prototypes will focus on long-lead time critical technologies for exascale and are reduced to support research for data-intensive science. In FY 2013, these efforts will focus on R&D in breakthrough technologies that will enable novel hardware designs for Exascale computing with priority given to early-stage technology development. These investments seek to minimize technical risk associated with exascale computing systems. By actively participating in the development of next-generation machines, ASCR can accelerate the development of technologies that enable exascale and ultimately accelerate and influence the development of architectures more appropriate for science. Also, researchers using the hardware will gain a better understanding of the inherent challenges of the hardware, both for leadership applications and data-intensive science, and begin to work on overcoming them.

In FY 2013, increased funding for Production Computing will support site preparations for a planned relocation of NERSC to a new computing facility. Both the Argonne and Oak Ridge Leadership Computing facilities will be upgraded to 10 petaflops in 2013 with reduced funding for infrastructure in FY 2013 to support the NERSC move. ESnet will begin production operation of a 100 gigabit per second optical network to select sites.

Program Planning and Management

ASCR planning and priority setting strongly benefits from input by outside experts. ASCR peer review and oversight processes are designed to regularly assess the quality, relevance, and performance of the ASCR portfolio.

The Advanced Scientific Computing Advisory Committee (ASCAC) provides input to ASCR by responding to charges from the Office of Science. For example, ASCAC organizes regular Committees of Visitors (COVs) to review ASCR research management, reviews of progress and bottlenecks in specific areas of research, reviews of the impact of ASCR scientific user facilities, and progress toward the long-term goals of the program. In addition, ASCAC identifies scientific challenges and opportunities, including specific bottlenecks to progress in areas such as climate change or computational biology. In FY 2011, ASCAC delivered a report on the opportunities and challenges associated with exascale computing. Also in 2011, a COV reviewed the Next Generation Networking for Science elements of the ASCR program. ASCAC provided input on the data policies of ASCR relevant communities, facilities, and publications, and an ASCAC subcommittee reviewed the management and impact of the Computational Sciences Graduate Fellowship.

The pace of progress in the computing industry requires ASCR to make more frequent and more dramatic changes in our portfolio than in other areas of basic research. However, this is not uniform across activities. For example, the development of robust, yet novel, applied mathematics for high performance computing can take sustained efforts over a decade or more while computer science changes dramatically in relatively short periods of time and networking research naturally progresses into production ready middleware and tools that are delivered via ESnet or program partners. ASCR goals for exascale computing require that the portfolio is continuously assessed and shifted to support critical new research efforts. In FY 2011, the Applied Mathematics activity redirected nearly $2,000,000 of effort toward new projects to develop algorithms and solvers for emerging architectures, the Computer Science activity renewed only 3 of 42 projects eligible for renewal in FY 2011 to make room for new efforts to address data movement and effective energy management in high performance computing systems, the Next Generation Networking for Science activity successfully completed projects representing more than half of the portfolio and is supporting new efforts to address the challenges of optical switches and high speed data flows, and the SciDAC portfolio was recompeted and streamlined to support petascale scientific discovery with application partners and the new exascale relevant co-design efforts in combustion, nuclear engineering and advanced materials.

Critical tools for managing ASCR scientific user facilities include tailored project management principles, annual operational reviews, and regular requirements gathering workshops. For example, ESnet and NERSC conduct requirements workshops with at least two SC program offices every year in order to accurately characterize their near-term, medium-term, and long-term network and computing requirements.

Other planning and management tools include community-driven workshops, the National Science and Technology Council's (NSTC) subcommittee on Networking and Information Technology Research and Development (NITRD), and studies by outside groups such as the National Research Council and the U.S. Council on Competitiveness.

Program Goals and Funding

Office of Science performance expectations (and therefore funding requests) are focused on four areas:

- *Research*: Enable high performance computational science and engineering to increase our understanding of and enable predictive control of phenomena in the physical and biological sciences.
- *Facility Operations*: Maximize the performance, usability, and capacity of the SC scientific computing user facilities and connect Office of Science researchers, labs and facilities via an ultra-reliable, high performance scientific network.
- *Future Facilities*: Build future and upgrade existing facilities and capabilities to get the best value from investments and advance continued U.S. leadership in computational science and engineering.
- *Scientific Workforce*: Continue to support graduate students and Post-Doc on research projects to ensure a sustained pipeline of highly skilled, computationally savvy, and diverse science, technology, engineering, and mathematics (STEM) workers.

Goal Areas by Subprogram

	Research	Facility Operations	Future Facilities	Workforce
Mathematical, Computational, and Computer Sciences Research	98%	0%	0%	2%
High Performance Computing and Network Facilities	10%	90%	0%	0%
Total, Advanced Scientific Computing Research	49%	50%	0%	1%

Explanation of Funding and Program Changes

(Dollars in Thousands)

	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Mathematical, Computational, and Computer Sciences Research	154,565	182,620	+28,055

New research will address the challenges of data-intensive science and the massive data expected from current and next generation scientific user facilities including new core research efforts in Applied Mathematics, Computer Science, and Next Generation Networking for Science that will address the full spectrum of data challenges from hardware to applications and new Computational Partnership investments focused on specific challenges of program partners.

	(Dollars in Thousands)		
	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
High Performance Computing and Network Facilities	286,303	272,973	-13,330
Increased funding for NERSC will support site preparations for relocation to a new computing facility. ESnet begins production use of 100Gbps optical ring. Both the Argonne and Oak Ridge LCFs will be upgraded to 10 petaflops with reduced funding for infrastructure investments.			
Research and Evaluation Prototypes is reduced to support research in data-intensive science and will focus on long-lead time R&D in breakthrough technologies that will enable novel hardware designs for Exascale computing with priority given to early-stage technology development.			
Total, Advanced Scientific Computing Research	440,868	455,593	+14,725

Mathematical, Computational, and Computer Sciences Research
Funding Profile by Activity

(Dollars in Thousands)

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Applied Mathematics	45,604	45,604	49,500
Computer Science	47,301	47,400	54,580
Computational Partnerships	52,813	44,250	56,776
Next Generation Networking for Science	12,313	12,751	16,194
SBIR/STTR	0[a]	4,560	5,570
Total, Mathematical, Computational, and Computer Sciences Research	158,031	154,565	182,620

[a] In FY 2011, $4,128,000 was transferred to the Small Business Innovation Research (SBIR) program and $496,000 was transferred to the Small Business Technology Transfer (STTR) program.

Overview

The Mathematical, Computational, and Computer Sciences Research subprogram supports activities aimed at effectively utilizing the Department's forefront computational and networking capabilities to advance DOE missions. Computational science is increasingly central to progress at the frontiers of science and to our most challenging engineering problems. Accordingly, the subprogram must be positioned to address scientifically challenging questions, to deliver:

- new mathematics required to more accurately model systems involving processes taking place on vastly different time and length scales such as the earth's climate and the behavior of living cells;
- software, tools and middleware to efficiently and effectively harness the potential of today's high performance computing systems and advanced networks for DOE science and engineering applications;
- operating systems, data management, analyses, representation model development, user interfaces, and other tools are required to make effective use of future-generation supercomputers and the data sets from current and future scientific user facilities;
- computer science and algorithm innovations that increase the energy efficiency of future-generation supercomputers; and
- networking and collaboration tools to make scientific resources readily available to scientists, regardless of whether they are in a university, national laboratory, or industrial setting.

Explanation of Funding Changes

The challenges of high performance computing systems on the path to exascale, the demands of DOE's data-intensive research, and the need for future collaborations and scientific user facilities require us to look ahead and make long-term, coordinated investments across the ASCR research portfolio with continuous monitoring of relevance and performance. For example, basic research in Applied Mathematics and Computer Science, coupled to expertise from the facilities, is required to realize the significant potential that exists in data produced by DOE research and facilities. Research in Computational Partnerships addresses application specific challenges, end user tools for data management and visualization, and challenges from emerging hardware. Next Generation Networking for Science provides the tools and middleware that enables moving and sharing facilities and collaboration data.

	(Dollars in Thousands)		
	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Applied Mathematics	45,604	49,500	+3,896
New research efforts will be supported to address the mathematical challenges of the massive quantities of high throughput data at scientific user facilities. These efforts will focus on novel mathematical analysis techniques necessary to understand and extract meaning from these massive datasets.			
Computer Science	47,400	54,580	+7,180
New research efforts will be supported to develop tools and software to address the challenges of data-intensive science and of capturing, storing, visualizing, and analyzing massive, high throughput data from scientific user facilities. These efforts will look at the full spectrum of computer science data challenges—from hardware to user interfaces and tools.			
Computational Partnerships	44,250	56,776	+12,526
New research efforts across this activity will engage partners across the Office of Science to address data challenges at the application level. One new Co-Design Center will be supported with a focus on the challenges to data-intensive science from emerging hardware. New Science Application partnerships will be added to focus on data challenges from the scientific user facilities, and a dedicated SciDAC Institute for Scientific Data Management Analysis and Visualization will also be supported.			
Next Generation Networking for Science	12,751	16,194	+3,443
New research efforts will be supported to address the challenges of moving, sharing, and validating massive quantities of data from DOE scientific user facilities and large scale collaborations. This includes the challenges in building, operating, and maintaining the network infrastructure over which these data pass.			
SBIR/STTR	4,560	5,570	+1,010
In FY 2011, $4,128,000 and $496,000 were transferred to the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs, respectively. SBIR/STTR funding is set at 2.95% of non-capital funding in FY 2012 and 3.05% in FY 2013.			
Total, Mathematical, Computational, and Computer Sciences Research	154,565	182,620	+28,055

Applied Mathematics

Overview

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

This activity supports the development of

- numerical methods related to problems such as fluid flow, magneto-hydrodynamics, wave propagation, and other natural or physical processes;
- computational meshing tools for developing ways in which physical domains can be efficiently partitioned into smaller, possibly geometrically complex, regions as part of a larger-scale simulation;
- advanced linear algebra libraries for fast and efficient numerical solutions of linear algebraic equations that often arise when simulating physical processes;
- optimization of mathematical methods for minimizing energy or cost, finding the most efficient solutions to engineering problems, or discovering physical properties and biological configurations;
- multiscale mathematics and multiphysics computations for connecting the very large with the very small, the very long with the very short, and multiple physical models in a single simulation;
- uncertainty quantification methodology and techniques to improve our overall understanding of complex scientific and engineering problems and allow us to make quantitative predictions about the behavior of these systems;
- efficient new mathematical models, algorithms, libraries, and tools for next generation computers that blur the boundary between applied mathematics and computer science;
- mathematics for the analysis of extremely large datasets for identifying key features, determining relationships between the key features, and extracting scientific insights from large, complex data sets; and
- mathematical optimization and risk assessment in complex systems such as cyber security or the electric grid that address anomalies in existing engineered systems, modeling of large-scale systems, and understanding dynamics and emergent behavior in these systems.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	Basic research activities continue for fundamental mathematical advances and computational breakthroughs across DOE and Office of Science missions—including model formulation and algorithm development to realize the potential from the ultra-low power, multicore-computing future. The Computational Science Graduate Fellowship (CSGF) program is funded at $6,000,000 within this activity.	45,604
2012 Enacted	The recompetition of mathematics of large datasets is delayed until 2013 to allow more workshops to focus these efforts on emerging challenges. This allows for increased support for Uncertainty Quantification in 2012. Uncertainty Quantification is important to understanding the results from petascale simulations and has been deemed critical to realizing the potential of exascale computing for predictive science. For many problems in the fields of natural sciences and engineering, incomplete descriptions, measurements, and data for these problems introduce uncertainties as	45,604

Fiscal Year	Activity	Funding ($000)
	researchers attempt to understand complex phenomena through computer modeling and simulation. As we increase the use of computing to study such problems, the development of more sophisticated techniques for the incorporation and quantification of uncertainties becomes key to our success. New efforts in the research and development of uncertainty quantification methodology and techniques will improve our overall understanding of complex scientific and engineering problems and allow us to make quantitative predictions about the behavior of these systems. The Computational Science Graduate Fellowship (CSGF) program is funded at $6,000,000.	
2013 Request	FY 2013 supports new and redirected research efforts to develop new algorithms and methods that address the challenges of data-intensive science. There are two broad categories in which DOE's missions lead to unique data-centric computing needs: advanced computing to simulate complex physical and engineering systems and DOE's advanced experimental resources. DOE researchers routinely compute detailed simulations of time-dependent 3D systems on the world's largest computers. These simulations generate enormous datasets that are difficult to extract and archive, let alone analyze. As leadership-class computers continue to grow in size, the data analysis problems will be a major scientific challenge. In addition, current DOE facilities and collaborations generate petabytes of data per year. Planned facilities will generate as much data each day. These trends present many challenges to the facilities and to the scientific user communities. Advancing data-intensive science is critical for understanding simulations of combustion, global climate modeling and cosmology, as well as understanding data from neutron scattering facilities, x-ray observatories, systems biology, and complex engineered systems such as the power grid. The increasing size and complexity of data related to DOE simulations, collaborations, and experimental facilities requires the development of novel mathematical analysis techniques to understand and extract meaning from these massive datasets. New methods are also necessary for analyzing and understanding uncertainty, especially in the face of noisy and incomplete data, and near real-time identification of anomalies in streaming and evolving data to detect and respond to phenomena that are either short-lived or urgent. New research efforts will focus on understanding, representing and learning from these massive DOE datasets. The Computational Science Graduate Fellowship (CSGF) program is funded at $6,000,000. New fellows in FY 2013 will be fully funded.	49,500

Computer Science

Overview

The Computer Science activity supports research to utilize computing at extreme scales and to understand extreme scale data from both simulations and experiments. Industry reports indicate that because of power constraints, data movement, rather than computational operations, will be the limiting factor for future systems. Memory per core is expected to decline sharply while the performance of storage systems will lag even further behind the computational capability of the systems. Multi-level storage architectures that span multiple types of hardware are anticipated and will require the Activity to support research that develops new approaches to run-time data management and analysis.

A fundamental challenge for researchers supported by this activity is enabling science applications to harness computer systems with increasing scale and increasing complexity that take advantage of technology advances such as multicore chips and specialized “accelerator” processors. This will require developing system software (operating systems, file systems, compilers, and performance tools) with more dynamic behavior than historically developed to deal with time varying power and resilience requirements. Substantial innovation is needed to provide essential system software functionality in a timeframe consistent with the anticipated availability of hardware.

This activity supports the development of: operating and file systems for extreme scale computers with many thousands of multi-core processors and complicated interconnection networks; performance and productivity tools for extreme scale systems that enable users to diagnose and monitor the performance of software and scientific application codes to enable users to improve performance and get scientific results faster; programming models that enable today’s computations and discover new models that scale to hundreds of thousands of processors to simplify application code development for petascale computing; approaches to simulate and understand the impact of advanced computer architectures on scientific applications critical to the Department; data management and visualization tools to transform extreme scale data into scientific insight through investments in visualization tools that scale to multi-petabyte datasets and innovative approaches to indexing and querying data; and efficient new mathematical models, algorithms, libraries, and tools for next generation computers that blur the boundary between applied mathematics and computer science.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	Basic research activities continue to enable critical DOE applications to utilize computing at extreme scales and to understand data from both simulations and experiments. This focus of efforts was critical to realizing the potential of ultra-low power, high performance multicore computing.	47,301
2012 Enacted	In FY 2012, the Computer Science activity focuses on the challenges of emerging extreme scale architectures containing as many as a billion cores and hybrid processors (such as mixed Central Processing Unit/Graphical Accelerator nodes). Research efforts continue in advanced architectures and related technologies for exascale computing including the associated software with significant investments in simulators for future systems.	47,400

Fiscal Year	Activity	Funding ($000)
2013 Request	FY 2013 supports new research efforts to address the challenges of data-intensive science with a focus on full data lifecycle management and analysis for the massive data from DOE scientific user facilities. These efforts will look at the full spectrum of the computer science data challenges from hardware to user interfaces and tools. This builds on decades of DOE leadership in this area of computer science and will be informed by recent ASCR workshops and reports including the requirements gathering workshops of NERSC and ESnet and the exascale series of workshops that identified many data challenges across DOE communities and those associated with the complexity of emerging hardware.	54,580

Computational Partnerships

Overview

The Computational Partnerships activity supports the Scientific Discovery through Advanced Computing (SciDAC) program to dramatically accelerate progress in scientific computing that delivers breakthrough scientific results through partnerships between applied mathematicians, computer scientists, and scientists from other disciplines. These efforts apply results from Applied Mathematics and Computer Science core research to scientific applications sponsored by other SC programs. These partnerships enable scientists to conduct complex scientific and engineering computations on leadership-class and high-end computing systems at a level of fidelity needed to simulate real-world conditions. SciDAC applications pursue computational solutions to challenging problems in climate science, fusion research, high energy physics, nuclear physics, astrophysics, material science, chemistry, particle accelerators, biology, and the reactive subsurface flow of contaminants through groundwater.

Over the past decade, SciDAC has influenced and shaped the development of a distinct approach to science and engineering research through high performance computation. Today the SciDAC program is recognized as the leader in accelerating the use of high-performance computing to advance the state of knowledge in science applications.

SciDAC focuses on the very high end of high performance computational science and engineering and faces two distinct challenges: to broaden the community and thus the impact of high performance computing, particularly to address the Department's missions, and to ensure that further progress at the forefront is enhanced rather than curtailed by the emergence of hybrid, multi-core architectures. A decade of effort has enabled this program to simultaneously meet both of these important challenges. SciDAC has also shown U.S. industry new ways to use computing to improve competitiveness.

Looking to the challenges of the future, the SciDAC portfolio was recompeted and streamlined in FY 2011 and FY 2012 to support strategic investments in petascale scientific discovery (Institutes and Science Applications) and Co-Design Centers focused on advancing applications that need exascale computing systems while informing the designs of the emerging hardware.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	Supported completion of the current SciDAC portfolio and ensured that results were published and tools widely distributed to broaden the impact of these efforts. The ten ASCR-led SciDAC Centers and Institutes awarded in FY 2006 were recompeted and replaced with three tightly integrated SciDAC Institutes in a restructuring of the program. The SciDAC Institutes are multi-institutional teams focused on delivering the applied mathematics and computer science needed for current scientific applications to make effective use of the multi-petaflop computing systems available in the near-term. These smaller, more closely integrated efforts provide a more efficient one-stop-shop for the scientific applications recompeted in FY 2012. Co-Design Centers are multi-institutional teams focused on understanding how to reformulate applications, algorithms and software (applied mathematics and computer science) to address the longer-term challenges of future computing systems with the intent to also influence the design of those systems and address the requirements of science and engineering. Three Co-Design Centers were initiated in FY 2011 with the selection of collaborations comprised of researchers in critical DOE applications (materials, combustion, and nuclear engineering), core Computer Science and Applied Mathematics researchers and hardware vendors. One important factor in the selection of these three particular applications areas was the fact that collectively they use and will advance	52,813

Fiscal Year	Activity	Funding ($000)
	many of the methods (structured and adaptive grids, dense and sparse linear algebra, particle methods, etc.) that span the DOE application space.	
2012 Enacted	In partnership with other Office of Science programs, ASCR is recompeting the Science Applications with a focus on the highest priorities of the partner programs and on development of community codes with sustained multi-petaflop performance. The selected applications will work with the ASCR-led SciDAC Institutes to enhance capabilities and ready codes for the 10 petaflop leadership computing systems available in FY 2013. These efforts will support areas such as nuclear physics, with relevance for basic research, national security, and nuclear engineering; earth system models to understand and quantify the impact of energy production and use on the environment; fusion simulations; accelerator design to make more effective use of existing facilities and inform plans for future facilities; combustion to improve the efficiency of fossil energy sources; and advanced materials for energy and national security applications. In addition, ASCR will establish a SciDAC Institute for Scientific Data Management, Analysis and Visualization to provide a single point of contact for scientists participating in the Science Applications to leverage ASCR expertise to more efficiently and effectively manage, analyze, visualize and understand their scientific data. The materials, combustion, and nuclear engineering Co-Design Centers will continue.	44,250
2013 Request	New research efforts will engage partners across the Office of Science to address the data-intensive science challenges at the science application level. ASCR will support an additional Co-Design Center with a focus on the challenges to data-intensive science from emerging hardware. This effort will engage SC scientific user facilities at forefront of the data challenge that are also dependant on leveraging commercially available hardware. In addition, new Science Applications will be added, in partnership with the other programs, to focus on the unique data challenges from their scientific user facilities. These efforts will be informed through a series of workshops such as the joint ASCR-BES workshop "*Data and Communications in Basic Energy Sciences: Creating a Pathway for Scientific Discovery*" held in early FY 2012. The dedicated SciDAC Institute for Scientific Data Management, Analysis and Visualization will continue to be supported as well as the other projects selected in FY 2011 and FY 2012.	56,776

Next Generation Networking for Science

Overview

To facilitate scientific collaborations, ASCR has played a leading role in driving development of the high-bandwidth networks connecting researchers to facilities, data, and each other. The invisible glue that binds today's networks—passing trillions of bits across the world—has roots in ASCR-supported research. For example, ASCR-supported researchers helped establish critical protocols on which the Internet is based. Next Generation Networking for Science research makes possible international collaborations such as the Large Hadron Collider and underpins virtual meeting and other commercial collaboration tools. These research efforts build upon results from Computer Science and Applied Mathematics to develop integrated software tools and advanced network services to utilize new capabilities in ESnet to advance DOE missions. These efforts broaden opportunities for other government agencies, U.S. industry, and the American people.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	Basic research activities continue to address advanced network technologies, high-performance software stacks, and distributed systems software to facilitate the distribution and sharing of scientific data generated by large-scale scientific collaborations. All networking research projects have a limited life span—research continues until tools and middleware are considered robust enough to be put into production on ESnet or in program-sponsored grid efforts such as the Open Science Grid. In FY 2011, 15 university and 16 national laboratory projects totaling $9,800,000 successfully completed their work, which was put into production. The successful completion of these projects enabled support of new research activities critical to realizing the potential from the prototype ultra-high throughput optical networks supported by the Advanced Networking Initiative to meet the growing needs large-scale scientific collaborations.	12,313
2012 Enacted	In FY 2012, research will continue to focus on developing networking software, middleware, and hardware that delivers 99.999% reliability while allowing the successful products of prior research to transition into operation. Research in this activity will continue to make critical investments, including new protocols that allow hosts to rapidly and efficiently adapt to network conditions to maximize the available bandwidth, new routing algorithms that can improve the performance of routers and switches, a rich suite of secure collaboration tools and services, and advanced simulation environments that duplicate real networks to ensure that science communities achieve their goals.	12,751
2013 Request	FY 2013 supports new research efforts to address the data-intensive science challenges facing scientific communities using unique DOE facilities and engaging in large-scale collaborations. Currently these user communities generate and share multi-petabyte datasets that pass through ESnet and are stored and shared within program-sponsored grids. These datasets will continue to grow, surpassing exabyte scales in the next few years. This presents many challenges in moving, sharing, analyzing, and validating such massive quantities of data. It also presents new challenges in building, operating, and maintaining the network infrastructure over which data passes. This activity focuses on developing new middleware and networking tools for moving, sharing, and verifying such massive datasets and on innovative analysis tools and services.	16,194

High Performance Computing and Network Facilities
Funding Profile by Activity

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
High Performance Production Computing	59,514	57,800	65,605
Leadership Computing Facilities	158,020	156,000	145,000
Research and Evaluation Prototypes	4,301	30,000	22,500
High Performance Network Facilities and Testbeds	30,451	34,500	32,000
SBIR/STTR	0[a]	8,003	7,868
Total, High Performance Computing and Network Facilities	252,286	286,303	272,973

[a] In FY 2011, $6,300,000 was transferred to the Small Business Innovation Research (SBIR) program and $756,000 was transferred to the Small Business Technology Transfer (STTR) program.

Overview

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

Computing resources are allocated through competitive processes. Up to 60% of the processor time on the LCFs is allocated through the Innovative and Novel Computational Impact on Theory and Experiment (INCITE) program, which is open to all researchers and results in awards to 20–30 large projects per year. The high performance production computing facilities at NERSC are predominately allocated to researchers supported by SC programs. Remaining processor time on the LCFs and NERSC is allocated through the ASCR Leadership Computing Challenge (ALCC). ALCC is open year-round to scientists from the research community in the national labs, academia and industry for special situations of interest to DOE with an emphasis on high-risk, high-payoff simulations in areas directly related to the DOE's energy mission, for national emergencies, or for broadening the community of researchers capable of using leadership computing resources.

Allocations on ASCR facilities provide critical resources for the scientific community following the public access model used by other SC scientific user facilities. In addition, ASCR facilities provide a crucial testbed for U.S. industry to deploy the most advanced hardware and have it tested by the leading scientists across the country in universities, national laboratories, and industry.

Explanation of Funding Changes

The challenges of developing and utilizing the ultra-low power, high performance multicore-computing systems on the path to exascale while meeting the demands of critical DOE applications require sustained, coordinated research and hardware investments across the ASCR research portfolio with innovation and collaboration key to continued progress. New Research and Evaluation prototype investments in critical technologies are central to these efforts.

	(Dollars in Thousands)		
	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
High Performance Production Computing	57,800	65,605	+7,805
Increase support for site preparations for the planned relocation of NERSC to a new computing facility.			
Leadership Computing Facilities	156,000	145,000	-11,000
LCFs upgraded to 10 petaflops with reduced funding for infrastructure investments.			
Research and Evaluation Prototypes	30,000	22,500	-7,500
Funds will support R&D in breakthrough technologies that will enable novel hardware designs for Exascale computing; awards will prioritize early-stage technology development. This activity is reduced to allow for investments in other areas to address the urgent challenges of data-intensive science.			
High Performance Network Facilities and Testbeds	34,500	32,000	-2,500
ESnet completes installation and begins production use of 100 Gbps optical ring.			
SBIR/STTR	8,003	7,868	-135
In FY 2011, $6,300,000 and $756,000 were transferred to the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs, respectively. SBIR/STTR funding is set at 2.95% of non-capital funding in FY 2012 and 3.05% in FY 2013.			
Total, High Performance Computing and Network Facilities	286,303	272,973	-13,330

High Performance Production Computing

Overview

This activity supports the National Energy Research Scientific Computing Center (NERSC) facility located at LBNL. NERSC delivers high-end production computing services for the SC research community. Annually, over 4,000 computational scientists in about 500 projects use NERSC to perform basic scientific research across a wide range of disciplines including astrophysics, chemistry, climate modeling, materials, high energy and nuclear physics, and biology. NERSC enables teams to perform modeling, simulation, and data analysis on some of the most capable computational and storage systems in the world to address some the biggest scientific challenges within the SC mission. NERSC users come from nearly every state in the U.S., with about 65% based in universities, 25% in DOE laboratories, and 10% in other government laboratories and industry. NERSC's large and diverse user base requires an agile support staff to aid users entering the high performance computing arena for the first time as well as those preparing codes to run across the largest machines available at NERSC and other SC computing facilities.

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

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	In FY 2011, this activity supported staff, operations and lease payments for the NERSC high-end capability systems—the 352 teraflop Cray XT4 (NERSC-5) and the newly upgraded over 1 petaflop Cray XE6 (NERSC-6). NERSC also provided users with access to smaller clusters and testbeds and the global storage systems that enable users to easily migrate to any of the available resources.	59,514
2012 Enacted	Support operation of the NERSC high-end capability systems (NERSC-5 and NERSC-6), lease payments, user support, and preparation for future system upgrades.	57,800
2013 Request	Supports staff, maintenance, operations and lease payments for the NERSC high-end capability systems, including an upgrade from NERSC-5 to a planned NERSC-7, while NERSC-6 remains in production. The NERSC-7 upgrade requires more power and space than available at the current site. NERSC will select a new site in 2012. The funding increase supports site preparations in FY 2013 for the planned relocation of NERSC to a new site.	65,605

Leadership Computing Facilities

Overview

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

The Oak Ridge Leadership Computing Facility (OLCF) 2.3 petaflop Cray XT5 system is one of the most powerful computers in the world for scientific research. Through INCITE allocations, several applications, including combustion studies in diesel jet flame stabilization, simulations of neutron transport in fast reactor cores, and groundwater flow in porous media, are running at the petascale. OLCF staff is sharing its expertise with industry to broaden the benefits for the Nation. For example, OLCF worked with Boeing to significantly reduce the need for costly physical prototyping and wind tunnel testing; with Ramgen to advance the development curve of their CO_2 compressor with a next generation rotor, which is scheduled for testing in early 2012; and with BMI trucking to increase fuel efficiency in 18 wheelers. The OLCF will complete its planned upgrade to 10 petaflops in FY 2013.

The Argonne Leadership Computing Facility (ALCF) provides a high performance 556 teraflop peak capability IBM Blue Gene/P with low-electrical power requirements. It will be upgraded in FY 2012 to the next generation system, an IBM Blue Gene/Q, with peak capability of approximately 10 petaflops. The Blue Gene/Q was developed through a joint research project with NNSA, IBM, and ASCR's Research and Evaluation Prototypes activity. The ALCF and OLCF systems are architecturally distinct and this diversity of resources benefits the Nation's HPC user community. ALCF supports many applications, including molecular dynamics and materials, for which it is better suited than OLCF or NERSC. Through INCITE, ALCF also transfers its expertise to industry, including working with Proctor and Gamble to study the complex interactions of billions of atoms to determine how tiny submicroscopic structures impact the characteristics of the ingredients in soaps, detergents, lotions, and shampoos, as well as in fire retardants and foams used in national security applications.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	In FY 2011, this activity supported staff, operations, and lease payments for the computer systems at the two Leadership Computing Facilities. Funding also supported significant investment in infrastructure equipment including storage arrays, network switches, and disks.	158,020
2012 Enacted	In FY 2012, this activity supports staff, operations, and lease payments. OLCF will complete site preparations and phase 1 of their upgrade of the Cray XT5 to a 10 petaflop Cray XK6 by replacing the processor boards and interconnects, while continuing to support users and managing INCITE allocations. At ALCF, installation and operation of an IBM Blue Gene/Q test and development system in early FY 2012 provides early science access to the Blue Gene/Q architecture, with installation of the full 10 petaflop upgrade completed by the end of FY 2012. The upgrade will be tested and a decision on acceptance made in FY 2013. In addition, the ALCF will support users and manage INCITE allocation of the Blue Gene/P.	156,000

Fiscal Year	Activity	Funding ($000)
2013 Request	In FY 2013, this activity supports staff, operations, and lease payments. OLCF will complete phase 2 of the upgrade with the addition of GPUs to a portion of the Cray XK6 cabinets taking it to 10 petaflops and will provide access to early science applications. Overall funding is reduced in FY 2013 due to reduced funding for infrastructure upgrades. ALCF will support full operation and INCITE allocations of the Blue Gene/Q with associated increased lease and power payments.	145,000

(Dollars in Thousands)

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Leadership Computing Facility at ANL	62,000	62,000	63,000
Leadership Computing Facility at ORNL	96,020	94,000	82,000
Total, Leadership Computing Facilities	158,020	156,000	145,000

Research and Evaluation Prototypes

Overview

DOE has been at the forefront of leadership computing for science and national security applications for decades. ASCR continues to invest in leadership class systems at Argonne and Oak Ridge, which play a key role in the health of the U.S. high performance computing industry. However, the challenges of the future require long-lead time investments in critical technologies. Research partnerships among ASCR, NNSA, the national laboratories, and researchers, including industry, are critical to ensuring that emerging systems are capable of meeting the demands of DOE mission applications—including our power restrictions. This will require basic research innovation from the underlying components to architectures—and the formulation of scientific applications that are tightly coupled to ASCR and NNSA co-design efforts. In addition to advancing DOE missions, these investments have the potential to dramatically impact the entire computing infrastructure for science, engineering, and industry by the end of the decade.

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

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	Completed SC's partnership with the NNSA and the Defense Advanced Research Projects Agency (DARPA) program for High Productivity Computing Systems. Expanded partnership with the NNSA to explore architectures on the path toward exascale computing.	4,301
2012 Enacted	ASCR will partner with NNSA and work with the research community, including industry, to deliver high bandwidth, power efficient memory technology for future computer systems. This activity will support basic research and development to optimize the performance and energy capabilities of emerging hybrid memory technology. These investments are critical because the current commercial roadmaps indicate that memory power requirements will dominate the power budgets for computers targeted at scientific and engineering applications. The goal of these efforts is to deliver low-energy, high performance memory with the 10–100 fold improvement over current commercial offerings that is required for DOE applications. This approach eases the path to broad commercial adoption in this decade—from individual laptops to servers—leading to energy efficiency gains across the information technology (IT) sector. In addition, this activity will support partnerships with NNSA and the research community, including industry, to advance the Department's goals for exascale computing. Significant technical challenges must be faced in meeting the needs of the computational science and engineering community over the next decade, among these are power, performance, concurrency, cost, and resiliency. The system goals are aggressive, and thus tradeoffs will be necessary—for example, reducing memory bandwidth would reduce system power but negatively affect science application performance.	30,000

Fiscal Year	Activity	Funding ($000)
2013 Request	This activity will continue research started in FY 2012 with NNSA and the research community, including industry, to develop critical technologies and low level software architectures that enable the creation of high performance scientific applications for these computers, as well as the smaller scale commercial versions that will be ubiquitous in the scientific infrastructure.	22,500

High Performance Network Facilities and Testbeds

Overview

The Energy Sciences Network (ESnet) provides the national network and networking infrastructure connecting DOE science facilities and SC laboratories with other institutions connected to peer academic or commercial networks. This network allows scientific users to effectively and efficiently access, distribute, and analyze the massive amounts of data produced by these science facilities.

The costs for ESnet are dominated by operations, including refreshing switches and routers on the schedule needed to ensure the 99.999% reliability required for large-scale scientific data transmission. Additional funds are used to support the testing and evaluation of new technologies and services that will be required to keep up with the data volume of new DOE facilities and unique DOE scientific instruments.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	In FY 2011, ESnet acquired the optical technologies and infrastructure needed to expand ESnet capacity and allow incremental upgrades over several years. The new infrastructure will support both scientific user communities' current production needs and allow for the creation of testbeds to experiment with new technologies and services in a contained environment. This testbed provides unique capabilities for networking and cyber security researchers to test new ideas and concepts at scale without risking disruption to production traffic. ESnet deployed a Nation-wide 100 gigabit-per-second (Gbps) prototype network in FY 2012 connecting the three ASCR computing facilities and the European peering point in New York. This prototype will allow ESnet to verify the operation of emerging 100 Gbps technologies.	30,451
2012 Enacted	ESnet will operate the network infrastructure to support critical DOE science applications and unique SC facilities. Building on 2011 procurements, ESnet will transition the 100 Gbps prototype network to production service replacing the 10 Gbps production link to this first segment of the ESnet backbone. In addition, 100 Gbps production network will be extended to additional SC laboratories by upgrading and connecting the Bay area metropolitan ring.	34,500
2013 Request	ESnet will operate the network infrastructure to support critical DOE science applications and SC facilities. ESnet will continue to extend deployment of 100 Gbps capacity to additional SC laboratories by upgrading additional segments of the backbone network and Metropolitan Area Networks to 100 Gbps speeds.	32,000

Supporting Information

Operating Expenses, Capital Equipment, and Construction Summary

(Dollars in Thousands)

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Operating Expenses	390,135	425,868	440,593
Capital Equipment	20,182	15,000	15,000
Total, Advanced Scientific Computing Research	410,317	440,868	455,593

Funding Summary

(Dollars in Thousands)

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Research	162,332	180,005	199,550
Scientific User Facility Operations	247,985	248,300	242,605
Other	0	12,563	13,438
Total, Advanced Scientific Computing Research	410,317	440,868	455,593

Scientific User Facility Operations

(Dollars in Thousands)

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
NERSC	59,514	57,800	65,605
OLCF	96,020	94,000	82,000
ALCF	62,000	62,000	63,000
ESnet	30,451	34,500	32,000
Total, Scientific User Facility Operations	247,985	248,300	242,605

Facilities Users and Hours

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
NERSC			
Achieved Operating Hours	8,474	N/A	N/A
Planned Operating Hours	8,585	8,585	8,585
Optimal Hours	8,585	8,585	8,585
Percent of Optimal Hours	98.7%	100%	100%
Unscheduled Downtime	1.3%	1%	1%
Number of Users	3,500	4,000	4,200

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
ESnet			
Achieved Operating Hours	8,760	N/A	N/A
Planned Operating Hours	8,760	8,760	8,760
Optimal Hours	8,760	8,760	8,760
Percent of Optimal Hours	99.999%	99.999%	99.999%
Unscheduled Downtime	0.001%	0.001%	0.001%
Number of Users [a]	N/A	N/A	N/A
OLCF			
Achieved Operating Hours	6,672	N/A	N/A
Planned Operating Hours	7,008	7,008	7,008
Optimal Hours	7,008	7,008	7,008
Percent of Optimal Hours	95.2%	100%	100%
Unscheduled Downtime	4.8%	1%	1%
Number of Users	625	625	700
ALCF			
Achieved Operating Hours	6,854	N/A	N/A
Planned Operating Hours	7,008	7,008	7,008
Optimal Hours	7,008	7,008	7,008
Percent of Optimal Hours	97.8%	100%	100%
Unscheduled Downtime	2.2%	1%	1%
Number of Users	350	350	450
Total			
Achieved Operating Hours	30,760	N/A	N/A
Planned Operating Hours	31,361	31,361	31,361
Optimal Hours	31,361	31,361	31,361
Percent of Optimal Hours	97.3%	100%	100%
Unscheduled Downtime	2.1%	1%	1%
Number of Users	4,475	4,975	5,350

[a] ESnet is a high performance scientific network that connects DOE facilities to researchers around the world and it is therefore not possible to estimate users.

Scientific Employment

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
# University Grants	210	210	210
Average Size	$232,000	$247,000	$262,000
# Laboratory Projects	180	175	188
# Graduate Students (FTEs)	563	563	614
# Permanent Ph.D.s (FTEs)	772	770	812
# Other (FTEs)	274	270	280

Basic Energy Sciences
Funding Profile by Subprogram

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Materials Sciences and Engineering			
Scattering and Instrumentation Sciences Research	68,254	64,721	73,721
Condensed Matter and Materials Physics Research	127,236	123,723	148,723
Materials Discovery, Design, and Synthesis Research	80,289	76,585	84,585
Experimental Program to Stimulate Competitive Research (EPSCoR)	8,520	8,520	8,520
Energy Frontier Research Centers (EFRCs)	58,000	58,000	68,000
Energy Innovation Hubs	0	19,410	24,237
SBIR/STTR	0	10,668	12,829
Total, Materials Sciences and Engineering	342,299	361,627	420,615
Chemical Sciences, Geosciences, and Biosciences			
Fundamental Interactions Research	71,394	67,562	71,562
Chemical Transformations Research	108,512	100,875	110,875
Photochemistry and Biochemistry Research	74,603	71,822	77,822
Energy Frontier Research Centers (EFRCs)	42,000	42,000	52,000
Energy Innovation Hubs	22,000	24,263	24,237
General Plant Projects (GPP)	6,615	200	2,315
SBIR/STTR	0	9,317	10,586
Total, Chemical Sciences, Geosciences, and Biosciences	325,124	316,039	349,397
Scientific User Facilities			
Synchrotron Radiation Light Sources	404,225	379,000	438,800
High-Flux Neutron Sources	255,850	249,068	257,694
Nanoscale Science Research Centers (NSRCs)	107,888	102,500	113,500
Other Project Costs	1,500	7,700	24,400
Major Items of Equipment	19,400	73,500	32,000
Research	30,928	24,545	27,000
SBIR/STTR	0	22,714	25,483
Total, Scientific User Facilities	819,791	859,027	918,877
Subtotal, Basic Energy Sciences	1,487,214	1,536,693	1,688,889

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Construction			
National Synchrotron Light Source-II (NSLS-II), BNL	151,297	151,400	47,203
Linac Coherent Light Source-II (LCLS-II), SLAC	0	0	63,500
Total, Construction	151,297	151,400	110,703
Total, Basic Energy Sciences	1,638,511[a]	1,688,093[b]	1,799,592

(Dollars in Thousands)

[a] Total is reduced by $39,684,000: $35,432,000 of which was transferred to the Small Business Innovation Research (SBIR) program and $4,252,000 of which was transferred to the Small Business Technology Transfer (STTR) program.
[b] The FY 2012 appropriation is reduced by $5,907,000 for the Basic Energy Sciences share of the DOE-wide $73,300,000 rescission for contractor pay freeze savings. The FY 2013 budget request reflects the FY 2013 impact of the contractor pay freeze.

Public Law Authorizations

Public Law 95-91, "Department of Energy Organization Act", 1977
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 Act of 2010"

Overview and Benefits

The mission of the 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 the BES program 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 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. The BES program 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 with the appropriate resolutions that can interrogate the inner workings of matter—transport, reactivity, fields, excitations, and motion—to answer some of the most challenging grand science questions. BES-supported activities stand at the dawn of an age 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, resulting in broad economic and societal impacts.

Major breakthroughs in clean energy technologies will arise from innovations 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 render today's internal combustion engine more efficient have their root in the transistor, whose development was critically dependent on the concept of quantum mechanics. At the core of such advances 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 from 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

For longer-term basic research to be relevant to the DOE technology programs that fund R&D toward specific near-to-mid-term needs, it is important to maintain strong, continual coordination activities between BES and other DOE program offices. R&D coordination is an integral characteristic of BES, which was formed in 1977 to link federally-funded fundamental research to energy technologies. 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; hydrogen production, storage, and use; 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. 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.

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.

New collaborative efforts with the Office of Energy Efficiency and Renewable Energy (EERE) will also be initiated through jointly funded R&D aimed at accelerating the transition of novel scientific discoveries into innovative, prototype clean energy technologies.

Program Accomplishments and Milestones

The following descriptions of recent accomplishments resulting from BES-supported research represent selected outcomes of the broad range of studies supported in the BES program. These few examples build on a large collection of BES accomplishments over the past few decades that in total portray remarkable discoveries of new knowledge, the rapidity with which scientific knowledge can often be incorporated into other research disciplines and into the commercial sector, and the great potential of basic research for future impacts on energy production and use.

New X-ray Sources Provide Unprecedented Probes of Matter. The Linac Coherent Light Source (LCLS) (the world's first x-ray free electron laser) provides capabilities that are revolutionizing our ability to image matter at the atomic scale. The intensity and ultrashort duration of LCLS x-ray pulses allow researchers to develop a new approach for determining the three dimensional structures of proteins. The laser's brilliant pulses of x-ray light pull structural data from tiny protein nanocrystals, avoiding the need to use large protein crystals that can be difficult or impossible to prepare. This technique will accelerate the structural analysis of some proteins by several years and will allow scientists to decipher tens of thousands of other macromolecules that are out of reach today, including many involved in energy technologies and biopharmaceutical applications.

Dynamic Solar Cells Capable of Self-repair. An artificial solar cell that mimics the self-repair process used by plants while they convert light into energy has been demonstrated for the first time. Long-term exposure to sunlight can damage solar cells leading to reductions in efficiency. Previously, only natural photosynthetic systems had shown the ability to disintegrate and then precisely reassemble complex light-harvesting machinery to repair photo-damage. An artificial system, made up of an ordered structure of carbon nanotubes, protein lipids, and bacterial photosynthetic reaction centers, was recently generated by directed self-assembly. The photoconversion efficiency of the artificial solar cell increased by over 300% through "self-repair" or regeneration over 168 hours of operation. These results provide a bioinspired design route to more robust, fault-tolerant solar energy conversion schemes that have the potential for indefinite extension of their lifetimes.

Superconductivity Better Understood. Important clues have been discovered to help unlock one of the long-standing mysteries of high-temperature superconductors—materials that conduct electricity at 100% efficiencies. An unanswered question centers on the origin and electronic behavior of the pseudogap phase, which is a non-superconducting state observed in a superconductor's electronic spectrum at temperatures above the superconducting state. Is the pseudogap phase a static state with a stable electronic structure or a dynamic state whose electronic structure fluctuates in time? Two new sets of measurements provide data that the pseudogap may display both features simultaneously. The results of these experiments provide very significant information toward understanding and identifying exactly what the pseudogap state is and how it affects superconductivity.

Magnetism Seen at an Atomic Scale. For the first time, the "spin" of atoms—the atomic behavior that controls the magnetic properties critical for computer hard drives and permanent magnets used in many technologies—has been imaged in an electron microscope. Being able to map spin at an atomic scale will provide the understanding to resolve many of the mysteries of magnetism. These experiments took advantage of new imaging techniques using our most advanced electron microscopes and focused on cobalt, a technologically important material found in batteries, magnets, and structural materials. This new imaging technique, coupled with predictive modeling, offers the potential to design and control the spin structure, enabling fine-tuning of the properties of materials.

Smart Microparticles Perform Robotic Functions. BES researchers recently demonstrated an innovative approach for the directed formation and manipulation of microparticle assemblies that can perform elaborate mechanical functions such as grasping, transporting, and releasing cargo. The ability to manipulate these structures is crucial for further development of dynamically responsive systems such as microrobots. They are made of magnetic microparticles confined between two non-mixing liquids which self-assemble into miniature star-like structures—asters—when energized by a magnetic field. By manipulating the magnetic field, individual asters and aster arrays can be directed to open and close around a target particle, swim, and then release the captured particle at a desired location. This discovery demonstrates control of functionality and opens new opportunities for design and fabrication of materials with self-repair, multi-tasking, and reconfiguring capabilities.

Breaking the Strongest Chemical Bonds Catalytically. Nitrogen (N_2) is converted to ammonia (NH_3) using catalysis through the Haber-Bosch process. It is arguably one of the most important chemical processes ever devised by man—approximately 50% of the world's population relies on the fertilizer derived from this process to grow their food supply. Unfortunately, it is also one of the most energy-intensive and heaviest carbon-dioxide-producing processes practiced by the chemical industry. Fundamental research in catalysis has resulted in new synthetic methods now promote these challenging chemical transformations under much milder conditions. For example, a hafnium metal complex has been discovered that uses carbon monoxide (CO) to break the N_2 bond, while making new carbon–carbon and carbon–nitrogen bonds. Adding some hydrogen creates oxamide, an important agrochemical that is currently made from fossil fuels. The whole process operates at ambient temperature, which is remarkable because it catalytically ruptures two of the strongest chemical bonds found in nature, those in N_2 and CO. This research begins to establish low-energy pathways to a broad variety of everyday products, such as fertilizers, pesticides and herbicides, polymers and polymer fibers, and pharmaceuticals.

Catalyst Mimics and Beats Nature. The conversion of electrical energy from intermittent energy sources, such as solar and wind, into chemical bonds is a proven and effective means of energy storage. The reverse conversion, from chemical to electrical energy, is equally effective at delivering the energy when it is needed. Catalysts are a critical component of the electrochemistry required for efficient inter-conversion between electrical and chemical energy. Researchers at the Center for Molecular Electrocatalysis, an Energy Frontier Research Center, have used a naturally occurring enzyme to guide the design of a remarkable new catalyst for producing hydrogen from electricity. The synthetic catalyst works a record-breaking 10 times faster than the original enzyme. The new synthetic catalyst and the natural enzyme both use the inexpensive, abundant metals nickel or iron in their design—a significant benefit over traditional electro-catalysts that use expensive metals like platinum or gold. The synthetic catalyst is readily produced in bulk and more likely to stand up to industrial conditions than the natural enzyme. This is an important breakthrough in electro-catalyst design that could enable the effective inter-conversion of electrical and chemical energy.

Splitting Water without the Bubbles. Researchers at the Joint Center for Artificial Photosynthesis (JCAP), which is the Fuels from Sunlight DOE Energy Innovation Hub, have created a proton exchange membrane (PEM) electrolyzer that splits water vapor to create hydrogen and oxygen. The new approach displays electrolysis rates higher than the current systems using liquid water. A key reaction in the pursuit of an artificial photosynthetic system is photo-electrolysis, or the splitting of water by sunlight. This process is usually run in liquid water and starts with a light absorber that captures energy from sunlight and utilizes a catalyst to drive the reaction. The products are gases, however, and their formation generates copious quantities of bubbles that inhibit the reaction by attenuating the amount of sunlight reaching the absorber and by slowing the transport of liquid water reactant to the catalyst. The PEM electrolysis of water vapor by the JCAP researchers involves no interference from bubbles. The fundamental insights gained from this discovery may lead to a whole new approach to photo-electrolysis, which, in turn, could alter the strategy for building a commercially viable solar fuels generation system.

Revolutionary Industrial Battery Technology Developed using Light Source Facilities. Battery experiments at the National Synchrotron Light Source and the Advanced Photon Source have provided the breakthroughs necessary to help launch a new line of heavy duty batteries and a new U.S. manufacturing facility. General Electric (GE) researchers used these facilities to measure the detailed chemical fluctuations of a commercial battery during charging and discharging in real time. Additional studies of cathode cross-sections helped the engineers further understand the evolution of battery chemistry at the interfaces within the system. The resulting new batteries—based on sodium metal halide technology—boast three times the energy density and charging power of lead-acid batteries, the current battery of choice for heavy duty applications. They also have expected lifetimes of up to twenty years and can operate in a wide range of temperature environments.

Milestone	**Date**
Complete a comprehensive peer review of all 46 Energy Frontier Research Centers.	3rd Qtr, FY 2012
Complete a Committee of Visitor's review of the Materials Sciences and Engineering subprogram.	3rd Qtr, FY 2012
Complete the pre-Critical Decision-2/3A review for the Linac Coherent Light Source-II (LCLS-II)	1st Qtr, FY 2013
Complete the LCLS Ultrafast Science Instruments (LUSI) project	4th Qtr, FY 2012
Complete the pre-Critical Decision-2/3A review for the Advanced Photon Source Upgrade (APS-U)	1st Qtr, FY 2013

Explanation of Changes

In FY 2013, BES will support the 46 Energy Frontier Research Centers, two Energy Innovation Hubs (*Fuels from Sunlight* and the *Batteries and Energy Storage)*, National Synchrotron Light Source-II (NSLS-II) construction and early operations, Linac Coherent Light Source-II (LCLS-II) construction, and the operations of the BES user facilities at near optimal levels. BES core research activities are flat funded with FY 2012. 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 2013.

In FY 2013, BES will also begin new research to enhance the role of science in supporting a clean energy agenda. The goal of this research is to develop the next generation of materials, chemicals, and game-changing processes based on a deeper scientific understanding of structure and properties across many scales: from atomic and molecular scales, through the nanoscale, and into the mesoscale. This research will enable science-based chemical and materials design and manufacturing through an understanding of the correlations between material structure, chemistry, and function. In the realm of energy, this means innovations in direct conversion of solar energy to fuels, in effective storage and transmission of electrical energy, in carbon capture and sequestration, and in the efficient use of energy.

Additional research efforts will be initiated to design materials with targeted properties and tailored chemical processes through theory, computation, and modeling, as validated by precise experimental characterization. Discovery of new materials and chemical assemblies with totally new properties and accurate predictions of their interactions with the environment are crucial to advances in energy technologies, as well as to virtually all industries that use materials in their products and manufacturing. The ultimate goal is to provide the Nation with a science-based computational tool set to rationally predict and design materials and chemical processes to gain a global competitive edge in scientific discovery and innovation.

New collaborative efforts with EERE will also be initiated through jointly funded R&D aimed at accelerating the transition of novel scientific discoveries into innovative prototype clean energy technologies. The joint efforts will ensure improved coordination of energy-related research across the Department and be focused on R&D activities aimed at overcoming the underlying physical challenges related to clean energy technology and designing and testing next-generation clean energy devices.

Program Planning and Management

The factors that are 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;
- 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;
- 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 the following four criteria, in order of decreasing importance: scientific and/or 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. Success rates vary, but approximately 10-20% of all BES research projects are terminated over the three-year review cycle, which creates a very dynamic program. 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 committees approximately biannually. 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 four 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.

Together these reports describe a continuum of research spanning the most fundamental questions of how nature works to the questions that address technological show-stoppers in the applied research programs supported by the DOE technology offices as well as by industry. Dealing with these issues requires breakthrough advances with new understanding, new materials, and new phenomena that will come from fundamental science. These reports will continue to inform the BES research agenda to bring frontier research to bear on addressing the Department's mission in science and energy. 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 latest COV was held on April 6–8, 2011, on the Chemical Sciences, Geosciences, and Biosciences subprogram, and the next COV will be in April 2012 on the Materials Sciences and Engineering subprogram. All COV reports and BES responses to COV recommendations are available on the BES website at http://science.energy.gov/bes/besac/bes-cov.

Program Goals and Funding

Basic Energy Sciences 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 to provide critical insights to the electronic,

atomic, and molecular configurations, often at ultrasmall length and ultrafast time scales.

- Future Facilities: Progress towards 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	6%	86%	8%	0%
Construction	0%	0%	100%	0%
Total, Basic Energy Sciences	46%	44%	10%	0%

Explanation of Funding Changes

	(Dollar in Thousands)		
	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Materials Sciences and Engineering	361,627	420,615	+58,988
Core research activities and EFRCs continue at the FY 2012 level. The Batteries and Energy Storage Innovation Hub continues. New research will be initiated for science supporting a clean energy agenda, materials and chemistry by design, and jointly funded R&D with EERE.			
Chemical Sciences, Geosciences, and Biosciences	316,039	349,397	+33,358
Core research activities and EFRCs continue at the FY 2012 level. The Fuels from Sunlight Innovation Hub continues. New research will be initiated for science supporting a clean energy agenda, materials and chemistry by design, and jointly funded R&D with EERE.			
Scientific User Facilities	859,027	918,877	+59,850
Increases in operations funding of the BES user facilities—five light sources, five Nanoscale Science Research Centers, and three neutron sources—allow for near optimal hours delivered to users. Early operations of the National Synchrotron Light Source-II at Brookhaven National Laboratory start in FY 2013. The APS Upgrade and NEXT MIE projects are also continued. New activities will be initiated at the facilities through jointly funded R&D with EERE.			

	(Dollar in Thousands)		
	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Construction	151,400	110,703	-40,697
Construction of the National Synchrotron Light Source-II (NSLS-II) will be ramped down, as scheduled (-$104,197,000) and the Linac Coherent Light Source-II (LCLS-II) begins funding as a construction project with PED and civil construction (+$63,500,000). The LCLS-II was funded as an MIE in FY 2012.			
Total, Basic Energy Sciences	1,688,093	1,799,592	+111,499

Materials Sciences and Engineering
Funding Profile by Activity

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Scattering and Instrumentation Sciences Research	68,254	64,721	73,721
Condensed Matter and Materials Physics Research	127,236	123,723	148,723
Materials Discovery, Design, and Synthesis Research	80,289	76,585	84,585
Experimental Program to Stimulate Competitive Research (EPSCoR)	8,520	8,520	8,520
Energy Frontier Research Centers (EFRCs)	58,000	58,000	68,000
Energy Innovation Hubs	0	19,410	24,237
SBIR/STTR	0	10,668	12,829
Total, Materials Sciences and Engineering	342,299	361,627	420,615

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 the existing knowledge base. 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 for a paradigm shift to enable the deterministic 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 electronic transport in batteries and fuel cells.

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

- **Scattering and Instrumentation Sciences**—The development of the 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; and
- **Materials Discovery, Design, and Synthesis**—How 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, 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)** supporting 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 a core group of **Energy Frontier Research Centers** that were established in FY 2009 and the **Batteries and Energy Storage Energy Innovation Hub** that is initiated in FY 2012. 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 electrochemical energy storage for vehicles and the electrical grid.

Explanation of Funding Changes

(Dollars in Thousands)

	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Scattering and Instrumentation Sciences Research	64,721	73,721	+9,000
Research increased for materials and chemistry by design to enhance experimental validation techniques (+$2,000,000) and for clean energy to advance scattering research to characterize relevant functionality in materials (+$7,000,000).			
Condensed Matter and Materials Physics Research	123,723	148,723	+25,000
Research increased for materials and chemistry by design to develop experimentally validated software including new theoretical tools (+$10,000,000) and for clean energy to explore mesoscale phenomena to advance new materials and functionalities for energy (+$15,000,000).			
Materials Discovery, Design, and Synthesis Research	76,585	84,585	+8,000
Research increased for materials and chemistry by design to develop experimentally validated computational tools for predictive materials synthesis (+$2,000,000) and for clean energy to explore related mesoscale phenomena to extend the lifetime and self-repair of materials and novel materials for carbon capture and storage (+$6,000,000).			
Experimental Program to Stimulate Competitive Research (EPSCoR)	8,520	8,520	0
Research continues at the FY 2012 level.			
Energy Frontier Research Centers (EFRCs)	58,000	68,000	+10,000
As part of the jointly funded R&D with EERE, increased funding will accelerate the transition of EFRC scientific discoveries into innovative, prototype clean energy technologies and enhance coordination between fundamental EFRC research and applied research and engineering development supported by EERE.			
Energy Innovation Hubs	19,410	24,237	+4,827
In FY 2013, Batteries and Energy Storage Hub operations are supported at the planned, annual level.			

	(Dollars in Thousands)		
	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
SBIR/STTR	10,668	12,829	+2,161
In FY 2011, $8,331,000 and $1,000,000 were transferred to the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs, respectively. SBIR/STTR funding is set at 2.95% of non-capital funding in FY 2012 and 3.05% in FY 2013.			
Total, Materials Sciences and Engineering	361,627	420,615	+58,988

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. Furthermore, recent advances in investigations of dynamic phenomena in real-time and relevant conditions provide a window into material functions under operational conditions. 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 ($000)
FY 2011 Current	Development of new instrumentation and techniques for ultrafast diffraction and imaging with x-rays and electrons for forefront materials research at these timescales continued to be emphasized. Spectroscopy and imaging research with neutron and x-ray scattering highlighted understanding material behavior at extreme conditions such as high pressures and temperatures. A new direction in scanning probe research was imaging functionality to understand properties of materials, including electrochemical reactions and transport.	68,254
FY 2012 Enacted	In FY 2012 research supports 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.	64,721
FY 2013 Request	The research will 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 will 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 will 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. These capabilities will open new regimes for materials research, especially to understand complex, use-inspired functionalities. Research in soft and hybrid materials will also be emphasized.	73,721

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Electron and Scanning Probe Microscopes	29,315	26,955	28,955
Neutron and X-Ray Scattering	38,939	37,766	44,766
Total, Scattering and Instrumentation Sciences Research	68,254	64,721	73,721

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—the solids, liquids, and mesoscale materials that make up the infrastructure for energy technologies at every level, including electronics, magnetic, optical, thermal, and structural materials.

A central focus is characterizing and understanding materials whose properties are driven by 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 electronic properties under extreme conditions such as ultra-low temperatures and extremely high magnetic fields. Research relevant to energy technologies includes understanding the elementary energy conversion steps in photovoltaics, 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 interactions of atomic particles and energy (quantum physics) 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 connection between the properties of materials and their size, shape, and composition are poorly understood.

The activity also emphasizes understanding how materials respond to their environment, such as 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 having superior mechanical properties and resistance to change under the influence of radiation.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
FY 2011 Current	Experimental and theoretical research continued to focus on understanding, designing, and controlling electronic and physical properties of materials through studies of the relationship of atomic-level structure to the electrical, optical, magnetic, surface reactivity, and mechanical properties of materials. Included were investigations of the ways in which materials respond to external stimuli such as stress, chemical and electrochemical environments, and radiation, as well as the proximity of materials to surfaces and interfaces.	127,236
FY 2012 Enacted	In FY 2012, combined computational and experimental research to develop validated theoretical models is enhanced. Research supports 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 continues on materials that underpin the evolution of energy technologies such as superconductors, radiation resistant materials, and photovoltaic, optical, and electronic applications. Research will be reduced in granular materials, surface diffusion and reconstruction, liquid crystals, and heat transfer in nanofluidics.	123,723
FY 2013 Request	The FY 2013 request continues 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 will be supported to provide new insights into the evolution of condensed matter behavior.	148,723

Fiscal Year	Activity	Funding ($000)

New research in materials and chemistry by design will emphasize development of validated software that can be used by the broader community, including the development of new theoretical tools that relate directly to clean energy technologies. Additional research will 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 will focus advancing our fundamental understanding of defects in materials that is needed to extend lifetimes and enhance performance of materials used in energy generation and use.

Research will 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.

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Experimental Condensed Matter Physics	47,610	46,781	51,281
Theoretical Condensed Matter Physics	29,623	31,623	41,623
Mechanical Behavior and Radiation Effects	18,953	17,582	23,082
Physical Behavior of Materials	31,050	27,737	32,737
Total, Condensed Mater and Materials Physics Research	127,236	123,723	148,723

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. Understanding how materials form is central to predictive discovery of new forms of matter with tailored properties. 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 the portfolio is biomimetic materials research—translating biological processes into impactful approaches to the design and synthesis of materials with the remarkable properties found only in nature, e.g., self-repair and adaptability to the changing environment. Research in Materials Discovery, Design, and Synthesis includes activities in Materials Chemistry and Biomolecular Materials, and Synthesis and Processing Science. This research underpins 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.

In Materials Chemistry and Biomolecular Materials, the emphasis is on chemistry- and biology-based approaches to materials synthesis and assembly. Major research directions include the controlled synthesis of nanoscale materials and their assembly into functional materials with desired properties; 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 dynamically; adaptive and resilient materials that also possess self-repairing capabilities. Synthesis and Processing Science supports fundamental research on the development of new methods and techniques to synthesize materials with desired structure and tailored properties. An important element of this activity is the development of real-time monitoring tools, diagnostic techniques and instrumentation to 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 ($000)
FY 2011 Current	In FY 2011, continuing scientific core research activities included: development of advanced methods to direct and control the assembly, symmetry, dimensionality, and functionality of materials; design and control of interfaces between dissimilar materials, including biological and non-biological systems in search of new materials and new phenomena; integration of theory, computation, and experiment to elucidate the mechanisms controlling synthesis and to further capabilities for materials discovery; and novel synthesis methods using extreme environments of field and flux.	80,289
FY 2012 Enacted	FY 2012 continues research to enhance the scientific foundations for understanding the fundamentals of synthesis, fabrication and processing for physical, chemical, and biomimetic materials. Additional emphasis will be included on integration of theory, computation, and experiment to enhance capabilities for materials discovery. Research will be reduced in activities that focus on ion beam assisted growth techniques, artificial enzymes, and synthesis of individual nanowires, particles, etc.	76,585

Fiscal Year	Activity	Funding ($000)
FY 2013 Request	Research will 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 will scale to larger quantities and result in resilient materials, porous materials modeled after biological membranes and related features. New directions in use-inspired clean energy research will consider 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 will take advantage of novel chemistries and approaches for gas storage and release, including innovative biomolecular materials research. Research will focus on obtaining a deeper understanding of the role of interfaces in the processes underpinning energy storage and catalytic technologies. Experimental research will also 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. Research will 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.	84,585

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Materials Chemistry and Biomolecular Materials	57,270	54,237	59,237
Synthesis and Processing Science	23,019	22,348	25,348
Total, Materials Discovery, Design, and Synthesis Research	80,289	76,585	84,585

Experimental Program to Stimulate Competitive Research (EPSCoR)

Overview

The U.S. Department of Energy's Experimental Program to Stimulate Competitive Research (DOE 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. The intent of EPSCoR is to help 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 places a high priority on promoting strong research collaboration between scientists and engineers in the designated states and territories with the world-class national laboratories, leveraging national user facilities, and taking advantage of opportunities for intellectual collaboration across the DOE system. This program is science-driven and supports the most meritorious proposals based on peer review and programmatic priorities.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
FY 2011 Current	Research supported a diversity of science and energy-related research topics. New research projects were initiated on conversion of solar and residual thermal energy to electricity and hydrogen and on chemical and mechanical degradation of battery materials.	8,520
FY 2012 Enacted	Continued support of basic research related to DOE mission areas. Collaborative efforts with DOE laboratories and user facilities will be enhanced.	8,520
FY 2013 Request	Efforts will continue to span science in support of the DOE mission, with emphasis on science underpinning the DOE energy technology programs broadly. Infrastructure-driven implementation grants will be enhanced.	8,520

EPSCoR Distribution of Funds by State

(Dollars in Thousands)

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Alabama	585	0	0
Alaska	0	0	446
Arkansas	0	0	0
Delaware	780	829	180
Hawaii	0	0	0
Idaho	0	0	0
Iowa	0	0	0
Kansas	0	0	0
Kentucky	590	590	590

(Dollars in Thousands)

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Louisiana	0	0	0
Maine	600	600	600
Mississippi	0	0	0
Montana	505	125	140
Nebraska	0	0	0
Nevada	0	0	0
New Hampshire	700	700	0
New Mexico	480	0	0
North Dakota	600	0	0
Oklahoma	0	0	422
Puerto Rico	770	770	770
Rhode Island	2,355	1,932	2,137
South Carolina	0	0	0
South Dakota	0	0	496
Tennessee	0	0	0
U.S. Virgin Islands	0	0	0
Utah	0	0	0
Vermont	0	0	0
West Virginia	300	300	0
Wyoming	0	0	407
Technical Support	255	260	275
Other[a]	0	2,414	2,057
Total, EPSCoR	8,520	8,520	8,520

[a] Uncommitted funds in FY 2012 and FY 2013 will be competed among all EPSCoR states.

Energy Frontier Research Centers

Overview

The Basic Research Needs workshops in 2003-2009 established the foundational basic research challenges that would enable major advances in energy technologies and retain U.S. leadership in innovations, inspired by research on grand science challenges. One of the recommendations was the need for assembling “multidisciplinary teams” of scientists and engineers to focus on these challenges. In response, the Energy Frontier Research Centers (EFRCs) were established in late FY 2009. These multi-investigator, multi-disciplinary centers foster, encourage, and accelerate basic research to provide the basis for transformative energy technologies of the future. There were 46 EFRC awards, 16 with full 5-year support from the American Recovery and Reinvestment Act of 2009. The remaining 30 are funded on an annual basis through this subprogram and the Chemical Sciences, Geosciences, and Biosciences subprogram. The initial 5-year initial award period will end in FY 2014.

The EFRCs are an important research modality, bringing together the skills and talents of a team of investigators to perform energy-relevant, basic research with a scope and complexity beyond that found in standard single-investigator or small-group awards. To help ensure their success, BES provides proactive oversight through regular and frequent interactions with the EFRCs, including meetings with the EFRCs as a group, and formal reviews, highlighted by an early management peer review (FY 2010) and the upcoming mid-term scientific peer reviews in FY 2012. To ensure communication of scientific research advances, technology needs, and program directions (to avoid duplication), management of the EFRC research includes coordination with other BES research activities and with the DOE technology offices.

In this activity, individual EFRCs perform a wide breadth of research in materials science and engineering that 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; improving the conversion of electricity to light; improving electrical energy storage; enhancing materials resistance to corrosion, decay, or failure in extreme conditions of temperature, pressure, radiation, or chemical exposures; taking advantage of emergent phenomena, such as superconductivity, to improve energy transmission; optimizing energy flow to improve energy efficiency; and tailoring materials and processes at the atomic level to maximize catalytic activity. Efforts to bridge disciplines, generate new avenues of inquiry, and accelerate research within the broader community include periodic all-hands meetings, joint symposia and workshops, summer schools, tool development, and principal investigators’ meetings.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
FY 2011 Current	The EFRCs continued their planned research activities and addressed Center specific guidance on areas that needed improvement based on the management review held in 2010. To communicate early research progress, the EFRC Summit and Forum was held and attended by over 1,000 people.	58,000
FY 2012 Enacted	The EFRCs complete their third year of operation in late FY 2012. To date, the 46 EFRCs have produced more than 1,000 peer reviewed publications and more than 90 invention disclosures or patent applications. In January-April 2012, a panel-based peer-review will assess the scientific progress of each EFRC. These reviews will also identify deficiencies and extraordinary performance.	58,000
FY 2013 Request	Research will incorporate modifications to research activities and directions resulting from the FY 2012 peer review. Additional funding will be provided to 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.	68,000

Energy Innovation Hubs

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. 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 enable inherently intermittent renewable energy sources to meet continuous electricity demand. For vehicles, new batteries with improved lifetimes and storage capacities are needed to expand range of electric vehicles' for 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 poor performance at high or low temperatures. The Batteries and Energy Storage Hub focuses on understanding the fundamental performance limitations for electrochemical energy storage to enable the next generation of electrochemical 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, devices, 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. The Hub's ultimate technological impact should go well beyond current research and development activities. 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 and 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 ($000)
FY 2011 Current	No funding was provided for the Hub.	0
FY 2012 Enacted	The Hub will be awarded through peer-review selection. The early stages of Hub research will be initiated. The Hub proposal and management plan will provide specific performance objectives and milestones. These will provide the baseline for future assessments of Hub progress.	19,410
FY 2013 Request	Hub research will follow the plan established in the proposal. A management peer review will take place to evaluate the Hub's progress in fulfilling the research plan. It is expected that the first scientific publications would appear, advisory groups would be operational (including industrial input), and a communications network would be established by the Hub.	24,237

Chemical Sciences, Geosciences, and Biosciences
Funding Profile by Activity

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Fundamental Interactions Research	71,394	67,562	71,562
Chemical Transformations Research	108,512	100,875	110,875
Photochemistry and Biochemistry Research	74,603	71,822	77,822
Energy Frontier Research Centers (EFRCs)	42,000	42,000	52,000
Energy Innovation Hubs	22,000	24,263	24,237
GPP	6,615	200	2,315
SBIR/STTR	0	9,317	10,586
Total, Chemical Sciences, Geosciences, and Biosciences	325,124	316,039	349,397

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 and at multiple levels of complexity.

At the heart of this research lies the quest to understand and control chemical reactions and the transformation of energy at the molecular scale in systems ranging from simple atoms and molecules, to active catalysts, to 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 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, and nanoscale 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 man-made 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 a core group of 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 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Fundamental Interactions Research	67,562	71,562	+4,000
Research increased for materials and chemistry by design for the use of optical fields to control and design quantum mechanical systems and new computational chemistry approaches to electronically excited states in molecules and extended systems (+$3,000,000). In science supporting the clean energy agenda, an increase for advanced combustion research to accelerate the predictive simulation of internal combustion engines (+$1,000,000).			
Chemical Transformations Research	100,875	110,875	+10,000
Research increased for materials and chemistry by design for the development of computational methods for the simulation of photo-catalytic, fuel-forming reactions and for complementary efforts in synthesis and characterization (+$2,000,000). In science supporting the clean energy agenda, increases for advanced catalytic approaches to the conversion of biomass to fuels and other chemical products, novel approaches to the separation of carbon dioxide from post-combustion gas streams and oxygen from air prior to oxy-combustion, actinide research in support of advanced nuclear energy systems, and research on the multi-scale dynamics of flow and plume migration in carbon sequestration (+$8,000,000).			

	(Dollars in Thousands)		
	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Photochemistry and Biochemistry Research	71,822	77,822	+6,000
Research increased for materials and chemistry by design for computational methods to simulate light harvesting and solar energy conversion to fuels and electricity (+$1,000,000). In science supporting the clean energy agenda, increases for studies or self-protection and repair of natural photosynthetic systems, research on the molecular level structure of the plant cell wall in order to elucidate catalytic routes for biomass conversion, and photocatalytic fuel generation (+$5,000,000).			
Energy Frontier Research Collaborations	42,000	52,000	+10,000
As part of the jointly funded R&D with EERE, an increase to accelerate the transition of EFRC scientific discoveries into innovative, prototype clean energy technologies and to improve coordination between fundamental EFRC research and applied research and engineering development supported by EERE (+$10,000,000).			
Energy Innovation Hubs	24,263	24,237	-26
In FY 2013, Hub operations are supported at the planned, annual level.			
GPP	200	2,315	+2,115
Funds are provided for facility improvements and upgrades at Ames Laboratory.			
SBIR/STTR	9,317	10,586	+1,269
In FY 2011, $7,684,000 and $922,000 were transferred to the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs, respectively. SBIR/STTR funding is set at 2.95% of non-capital funding in FY 2012 and 3.05% in FY 2013.			
Total, Chemical Sciences, Geosciences, and Biosciences	316,039	349,397	+33,358

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, and nanoscale 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.

This activity's 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 this foundation by examining reactive chemistry of molecules that are not isolated, but whose chemistry is profoundly affected by the environment. It confronts 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. 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—a full description of the burning of diesel fuel requires thousands of chemical reactions. 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 for the study of combustion science.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
FY 2011 Current	Current topics in AMO science included interactions of atoms and molecules with intense electromagnetic fields; collisions and highly correlated interactions of atomic and molecular systems; and the development and application of novel, ultrafast optical probes of matter, particularly x-ray sources. In chemical physics research, current topics included studies of the dynamics and rates of gas-phase chemical reactions at energies characteristic of combustion, identification key combustion intermediates, and understanding their chemical and physical properties, as well as development of new experimental and theoretical techniques. These underpin the development of robust and fully predictive simulation capabilities for turbulent combustion, which is critical to enable efficient and clean use of renewable and fossil fuels.	71,394

Fiscal Year	Activity	Funding ($000)
FY 2012 Enacted	Core research activities continue with emphasis on the development and application of new ultrafast x-ray and optical probes of matter. Additional new research emphasizes 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.	67,562
FY 2013 Request	AMO sciences research will 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 will emphasize 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 are provided 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 is provided for advanced combustion research to accelerate the predictive simulation of internal combustion engines.	71,562

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Chemical Physics Research	48,264	46,492	49,492
Atomic, Molecular, and Optical Science	23,130	21,070	22,070
Total, Fundamental Interactions Research	71,394	67,562	71,562

Chemical Transformations Research

Overview

This activity 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 nanoscale catalysts that 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 ($000)
FY 2011 Current	Current topics in catalysis science include the chemistry of inorganic, organic, and hybrid porous materials and their self-assembly into functional catalytic systems. Emphasis was placed on elucidating the elementary steps of catalytic reaction mechanisms and their kinetics, the construction of catalytic sites at the atomic level, and synthesis of molecular catalysts that are often inspired by natural systems. Breakthroughs in directed chemical synthesis enabled the design of membranes and filters that can distinguish and sort even very similar molecules, such as nitrogen and oxygen, or carbon dioxide and methane. SC synchrotron light sources and leadership class computational facilities were used to advance our understanding of new actinide-ligand complexes whose basic chemistry is not well understood, but that hold great potential as next-generation nuclear fuels. Nanoscale geochemistry and biogeochemistry studies provided measurement and monitoring techniques, and understanding to validate predictive models for subsurface transport.	108,512
FY 2012 Enacted	Core research activities continue and include emphasis on the combination of computational design, directed synthesis, and molecular-scale characterization to create and optimize novel catalysts. Other areas of research emphasis include 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.	100,875

Fiscal Year	Activity	Funding ($000)
FY 2013 Request	As part of the materials and chemistry by design effort, an increase is 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 are provided 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 are provided 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.	110,875

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Catalysis Science	49,656	49,650	53,650
Separations and Analysis	15,415	14,193	16,193
Heavy Element Chemistry	15,108	14,751	16,751
Geosciences Research	28,333	22,281	24,281
Total, Chemical Transformations Research	108,512	100,875	110,875

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 as well as bio-hybrid systems that exhibit the biological traits of self assembly, regulation, and self repair. 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 man-made 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 ($000)
FY 2011 Current	An area of significant focus was the biological machinery involved in light-driven water splitting (photolysis), arguably the most demanding reaction in nature. The bonds between hydrogen and oxygen atoms in water must first be broken, before the atoms can be reformed into a fuel. Drawing from the natural blueprint, a new class of metal-based complexes that are a thousand times more active than previous generations have recently been synthesized. This significant advancement results from the ability of a single metal atom to complex with organic ligands in far more configurations than previous designs. Other current topics included advances in photo-electrochemistry, which is an alternative to semiconductor photovoltaic cells for electricity generation from sunlight using closed, renewable cycles. The plant cell wall is where biology stores solar energy in the form of complex macromolecules. Therefore a current focus was on understanding of cell wall architecture at the molecular level, which is required for catalytic conversion of biomass into chemical fuels.	74,603
FY 2012 Enacted	The continuation of ongoing research activities includes 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 will continue to understand the biophysical and biochemical parameters that make the plant cell wall recalcitrant to catalytic conversion into fuels and other value-added products.	71,822

Fiscal Year	Activity	Funding ($000)
FY 2013 Request	As part of the materials and chemistry by design effort, an increase is provided 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 are provided 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).	77,822

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Photosynthetic Systems	17,424	17,424	19,424
Physical Biosciences	17,112	16,147	18,147
Solar Photochemistry	40,067	38,251	40,251
Total, Photochemistry and Biochemistry Research	74,603	71,822	77,822

Energy Frontier Research Centers

Overview

The Basic Research Needs workshops in 2003-2009 established the foundational basic research challenges that would enable major advances in energy technologies and retain U.S. leadership in innovations, inspired by research on grand science challenges. One of the recommendations was the need for assembling multidisciplinary teams of scientists and engineers to focus on these challenges. In response, the Energy Frontier Research Centers (EFRCs) were established in late FY 2009. These multi-investigator, multi-disciplinary centers foster, encourage, and accelerate basic research to provide the basis for transformative energy technologies of the future. There were 46 EFRC awards, 16 with full 5-year support from the American Recovery and Reinvestment Act of 2009. The remaining 30 are funded on an annual basis through this subprogram and the Materials Sciences and Engineering subprogram. The initial 5-year initial award period will end in FY 2014.

The EFRCs are an important research modality, bringing together the skills and talents of a team of investigators to perform energy-relevant, basic research with a scope and complexity beyond that found in standard single-investigator or small-group awards. To help ensure their success, BES provides proactive oversight through regular and frequent interactions with the EFRCs, including meetings with the EFRCs as a group, and formal reviews, highlighted by an early management peer review (FY 2010) and the upcoming mid-term scientific peer reviews in FY 2012. To ensure communication of scientific research advances, technology needs and program directions (to avoid duplication), management of the EFRC research includes coordination with other BES research activities and with the DOE technology offices.

The EFRCs in this activity are focused on the design, discovery, control, and characterization of 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. Unifying themes in the research include the fundamental understanding of interfacial phenomena underlying the transport of electrons, atoms, molecules, and energy at the nanoscale and the development and application of new experimental and theoretical tools for molecular-scale understanding of complex chemical, biochemical, and geological processes. Efforts to bridge disciplines, generate new avenues of inquiry, and accelerate research within the broader community include periodic all-hands meetings, joint symposia and workshops, summer schools, tool development, and principal investigators' meetings.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
FY 2011 Current	The EFRCs continued their planned research activities and addressed Center specific guidance on areas that needed improvement based on the management review held in 2010. To communicate early research progress, the EFRC Summit and Forum was held and attended by over 1,000 people.	42,000
FY 2012 Enacted	Continued support of ongoing research activities. The EFRCs complete their third year of operation in late FY 2012. To date, the 46 EFRCs have produced more than 1,000 peer reviewed publication and more than 90 invention disclosures or patent applications. In January-April 2012, a panel-based peer-review will assess the scientific progress of each EFRC. These reviews will also identify deficiencies and extraordinary performance.	42,000

Fiscal Year	Activity	Funding ($000)
FY 2013 Request	Research will incorporate modifications to research activities and directions resulting from the FY 2012 peer review. Additional funding will be provided to 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.	52,000

Energy Innovation Hubs

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 lead 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. As there is currently no direct solar-to-fuels industry in the world, JCAP has the potential for profound environmental and economic impact—establishing U.S. global leadership in renewable energy, reducing our dependence on imported oil, decreasing greenhouse gas emissions, and providing new jobs in an emerging energy technology.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
FY 2011 Current	JCAP's first year of operation was devoted to project development: establishing research facilities, hiring personnel, setting-up collaborative agreements, and instituting an overall business model. DOE oversight included monthly teleconferences between JCAP management and DOE staff, quarterly and annual written reports, informal site visits, and a reverse-site review accessing JCAP's management and early operations (April 2011). Notably, the DOE external review panel unanimously commented on the imperative need for a Fuels From Sunlight Hub to integrate the various constituents of the solar fuels community and found that JCAP has an ambitious vision and an aggressive strategy to achieve its very challenging goal. All operations at LBNL are housed in a newly renovated, 14,000 square foot laboratory and the renovations of laboratory space for JCAP on the Caltech campus are on schedule. Initial research supported through JCAP includes the synthesis and characterization of earth-abundant semiconductor materials with suitable band gaps for water splitting and carbon dioxide activation; the design of a new high throughput screening system for the preparation and testing up to one million semiconductor formulations per day; and the establishment of parameters for catalyst benchmarking for water splitting and carbon dioxide activation studies that will compare the reactivity and selectivity of catalysts from around the world in the same prototype devices, under the same experimental conditions. Early JCAP research has resulted in several invention disclosures and scientific manuscripts.	22,000

Fiscal Year	Activity	Funding ($000)
FY 2012 Enacted	In FY 2012, renovations of the permanent facility for JCAP on the Caltech campus will be completed and ready for occupancy by all JCAP staff from Caltech and the University of California partners. JCAP staffing will continue to grow toward a steady state of 150–180 scientists and engineers, with an additional 30–50 visitors from the Energy Frontier Research Centers, other DOE Programs, and other countries. The Hub will increase efforts to integrate the solar fuels community through symposia and workshops, tool development, and principal investigators' meetings. In April 2012, an external peer review will assess the scientific and technical progress of the Hub. These reviews will identify any deficiencies as well as areas of extraordinary performance.	24,263
FY 2013 Request	In FY 2013, areas of increased emphasis will 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. It is expected that FY 2013 will bring extensive collaboration between the external scientific and technical communities and JCAP in order to test and redesign light absorbers and catalysts. It is also expected that there will be significantly increased interactions with and/or licensing to industry in order to develop targeted direct solar fuels technologies.	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 in 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 ($000)
FY 2011 Current	In addition to minor facility improvements at Ames Laboratory, the CRF, and the Notre Dame Radiation Laboratory, funding was provided to Ames for planning of infrastructure upgrades. Funding was also provided for the seismic retrofit of the CRF office building to ensure safe office conditions for the BES-supported researchers.	6,615
FY 2012 Enacted	FY 2012 funding will support minor facility improvements at Ames Laboratory.	200
FY 2013 Request	Funding will support minor infrastructure improvements and upgrades at Ames Laboratory.	2,315

Scientific User Facilities
Funding Profile by Activity

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Synchrotron Radiation Light Sources	404,225	379,000	438,800
High-Flux Neutron Sources	255,850	249,068	257,694
Nanoscale Science Research Centers (NSRCs)	107,888	102,500	113,500
Other Project Costs	1,500	7,700	24,400
Major Items of Equipment	19,400	73,500	32,000
Research	30,928	24,545	27,000
SBIR/STTR	0	22,714	25,483
Total, Scientific User Facilities	819,791	859,027	918,877

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. These 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 user facilities are visited by more than 11,000 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 produce 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 offer critical scientific insights for 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 impacts 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 FY 2013 budget request fulfills stewardship responsibilities to ensure the optimal operations and continual upgrades in capabilities. The budget request supports the upgrade of the Advanced Photon Source. FY 2013 will also see the early operations of the National Synchrotron Light Source-II (NSLS-II) in preparation for full operations in FY 2015. 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 FY 2013 request provides near optimal operations of all facilities.

New collaborative efforts with EERE will also be initiated at BES scientific user facilities to accelerate the transition of novel scientific discoveries into innovative, prototype clean energy technologies. The joint efforts will ensure improved coordination of energy-related research across the Department and be focused on characterization activities aimed at overcoming the underlying physical challenges related to clean energy technology and designing and testing next-generation clean energy devices. Within the user facilities, these efforts will focus on expanding the available experimental toolkit to enable research in this area.

(Dollars in Thousands)

	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Synchrotron Radiation Light Sources	379,000	438,800	+59,800
Increases in operations funding allow for near optimal hours delivered to users. The National Synchrotron Light Source-II at Brookhaven National Laboratory begins early operations in FY 2013. New activities will be initiated at the facilities through jointly funded R&D with EERE.			
High-Flux Neutron Sources	249,068	257,694	+8,626
Increases in operating funding allow for near optimal hours delivered to users. New capabilities and user capacity will be added at the Spallation Neutron Source at Oak Ridge National Laboratory.			
Nanoscale Science Research Centers (NSRCs)	102,500	113,500	+11,000
Increases in operations funding allow for near optimal hours delivered to users. New activities will be initiated at the facilities through jointly funded R&D with EERE.			
Other Project Costs	7,700	24,400	+16,700
Funding is provided to support other project costs related to NSLS-II construction according to the project profile. The increase supports the preparation for the startup of NSLS-II.			
Major Items of Equipment	73,500	32,000	-41,500
Funding will be provided to ensure continual upgrade of light source capabilities and instruments. The SING-II project final year of funding is FY 2012 (-$11,500,000) and the LCLS-II is included as a construction project in the FY 2013 request (-$30,000,000).			

	(Dollars in Thousands)		
	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Research	24,545	27,000	+2,455
Increased funding to support accelerator and detector research and the electron beam microcharacterization centers.			
SBIR/STTR	22,714	25,483	+2,769
In FY 2011, $19,417,000 and $2,330,000 were transferred to the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs, respectively. SBIR/STTR funding is set at 2.95% of non-capital funding in FY 2012 and 3.05% in FY 2013.			
Total, Scientific User Facilities	859,027	918,877	+59,850

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, ceramics, polymers, catalysts, plastics, and biological molecules. 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. Synchrotron radiation is, in the newest facilities, billions of times brighter than the light from conventional x-ray sources. 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 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), Stanford Synchrotron Radiation Lightsource (SSRL), and a Free Electron Laser, the Linac Coherent Light Source (LCLS) at SLAC National Accelerator Laboratory (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 ($000)
FY 2011 Current	Funds have been provided to operate the BES synchrotron radiation light sources that are available to thousands of users yearly. Funding is also included for the first full year of operations of the newly completed LCLS.	404,225
FY 2012 Enacted	Funds are provided to support the continued operations of the BES synchrotron radiation light sources. The FY 2012 funding is below the optimal level and will likely impact machine maintenance and user support.	379,000
FY 2013 Request	In FY 2013, funding is requested 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.	438,800

Fiscal Year	Activity	Funding ($000)
	New collaborative efforts with EERE will also be initiated at BES light sources to accelerate the transition of novel scientific discoveries into innovative, prototype clean energy technologies. Funding will support procurement of instrumentation dedicated to clean energy research.	

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Advanced Light Source, LBNL	59,600	62,000	70,000
Advanced Photon Source, ANL	137,175	123,000	134,800
National Synchrotron Light Source, BNL	41,500	36,000	39,500
National Synchrotron Light Source-II, BNL	0	0	22,000
Stanford Synchrotron Radiation Lightsource, SLAC	34,950	34,000	42,000
Linac Coherent Light Source (LCLS), SLAC	131,000	124,000	130,500
Total, Synchrotron Radiation Light Sources	404,225	379,000	438,800

High-Flux Neutron Sources

Overview

The goal of modern materials science is to understand the factors that determine the properties of matter on the atomic scale, and then 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 several unique advantages: they have a wavelength similar to the spacing between atoms for studying structure with atomic resolution, and an energy similar to that of atoms in materials for investigating their 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. Finally, their scattering cross-section is precisely measurable on an absolute scale, facilitating straightforward comparison with theory and computer modeling.

One way of generating neutrons is via fission in a research reactor—the High Flux Isotope Reactor (HFIR) at Oak Ridge National Laboratory (ORNL) is this type of neutron source. Another approach 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. Since accelerators are naturally pulsed, the resulting neutron source is also pulsed, enabling a highly efficient use of the neutrons produced in time-of-flight experiments.

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. 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 the dynamics of a wide range of materials, and two small-angle scattering spectrometers at the recently installed liquid-hydrogen cold source for measuring structures of condensed matter and biological materials on nm-µm length scales provides are best in their class world-wide. The Lujan Center, a pulsed spallation source operating at about 100 kW, supports a target hall constructed by SC and instruments fabricated by SC and NNSA that address the needs of both the basic research community and the NNSA mission of science-based stockpile stewardship.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
FY 2011 Current	Funding was provided to support the operations of the three BES neutron scattering facilities. All three have seen a continuing growth in scientific productivity and users. FY 2011 was the first full year of operation of the diffractometer for studying the structure of nanoscale-disordered materials (built at SNS under the SING-I project).	255,850
FY 2012 Enacted	Funding is provided to support the operations of the three BES neutron scattering facilities. The funding will support the operations of additional instruments that are coming online at the SNS. FY 2012 will be 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. The FY 2012 funding is below the optimal level and will likely impact machine maintenance and user support.	249,068

Fiscal Year	Activity	Funding ($000)
FY 2013 Request	Additional funding is requested to provide near optimal support for user operations. This will be the first full year of operation of the new chemical spectrometer instrument at SNS.	257,694

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Spallation Neutron Source, ORNL	181,300	180,568	187,194
High Flux Isotope Reactor, ORNL	60,200	58,000	60,000
Intense Pulsed Neutron Source, ANL	3,000	0	0
Lujan Neutron Scattering Center, LANL	11,350	10,500	10,500
Total, High-Flux Neutron Sources	255,850	249,068	257,694

Nanoscale Science Research Centers (NSRCs)

Overview

Nanoscience is the study of materials and their behaviors at the nanometer (nm) scale—probing single atoms, clusters of atoms, and molecular structures. The scientific quest is to design, observe, and understand how these systems 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 the 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: 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 via external peer review of user proposals.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
FY 2011 Current	Funding supported continued operations of the five NSRCs, which are routinely available to users during normal operating hours. Funding also supported capital equipment for nanofabrication and characterization, and computer modeling.	107,888
FY 2012 Enacted	In FY 2012, funding is 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. The FY 2012 funding is below the optimal level and will likely impact maintenance and user support.	102,500
FY 2013 Request	An increase in funding is requested to support near optimal operations of the five NSRCs. Continued emphasis will 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. The NSRCs will continue to cultivate and expand its user base from universities, national laboratories, and industry. New collaborative efforts with EERE will also be initiated at the NSRCs to accelerate the transition of novel scientific discoveries into innovative, prototype clean energy technologies. Funding will support procurement of instrumentation dedicated to clean energy research.	113,500

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Center for Nanoscale Materials, ANL	22,047	20,500	22,700
Center for Functional Nanomaterials, BNL	20,471	20,000	22,700
Molecular Foundry, LBNL	22,313	20,500	22,700
Center for Nanophase Materials Sciences, ORNL	21,758	20,500	22,700
Center for Integrated Nanotechnologies, SNL/LANL	21,299	21,000	22,700
Total, Nanoscale Science Research Centers (NSRCs)	107,888	102,500	113,500

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 the 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. OPCs are all other costs related to the projects that are not included in the TEC. Generally, OPC are 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 are always funded via operating funds.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
FY 2011 Current	Funds were provided in FY 2011 for other project costs associated with the National Synchrotron Light Source-II (NSLS-II) at BNL.	1,500
FY 2012 Enacted	Funds are provided in FY 2012 for other project costs associated with the NSLS-II at BNL.	7,700
FY 2013 Request	Funds are requested in FY 2013 for other project costs associated with the NSLS-II at BNL according to the project plan. The increase supports the preparation for the startup of NSLS-II.	24,400

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 new x-ray and neutron experimental stations, improve core facilities, and provide 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

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, along with the ESRF in France and Spring-8 in Japan, is only one of three in the world. 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 or improved materials, and biological studies. The upgraded APS will complement the capabilities of the 4th generation light sources (e.g., Linac Coherent Light Source (LCLS)), which occupy different spectral, flux, and temporal range of technical specifications. The project is managed by Argonne National Laboratory. The LCLS facility, commissioned in April 2009, has been a success, from conception to construction, and into operation. This success has prompted the LCLS-II Project, which is to expand the x-ray spectral operating range and the user capacity. The LCLS-II is supported as an MIE in FY 2012 and will be funded as a construction project starting in FY 2013. The change in funding mode was informed and validated by a pre-CD-1 Lehman review in FY 2011. 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 to be provided by the SING-I project.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
FY 2011 Current	After receiving Critical Decision-0 (CD-0) Approve Mission Need in FY 2010, the APS-U completed conceptual design and received CD-1 approval during the 4th quarter of FY 2011. Similarly, the LCLS-II and the NEXT projects also achieved CD-0 in FY 2010. The SNS PUP was placed on indefinite hold after a Critical Decision-2 (CD-2) readiness review, which showed significant projected growth in cost and schedule. The Spallation Neutron Source Instrumentation Next Generation (SING-I) project successfully completed and was transitioned to operations for commissioning. SING-II achieved Critical Decision 3 (CD-3) Approve Start of Construction, and began its construction phase for the fourth and final instrument in the project.	19,400
FY 2012 Enacted	The APS-U project will enter the preliminary design phase post CD-1 and will begin preparations to seek approvals for CD-2, which establishes the project baselines, and CD-3A, which authorizes long lead procurements. After receiving CD-1 approval during the 1st quarter of FY 2012, LCLS-II will work on design, in-house fabrication, long lead procurement, construction of an annex building, exploration and design of the two-tunnel option, and project management. While LCLS-II is supported as an MIE in FY 2012, it will be funded as a construction project starting in FY 2013. The NEXT project achieved CD-1 in early 2012, which provides an alternative selection and cost range for this project. SING-II will receive its last year of funding and is scheduled to complete and start operations of its first instrument, the Vibrational Spectrometer (VISION).	73,500
FY 2013 Request	APS-U and NEXT will 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 will be continuing fabrication of the neutron scattering instruments during FY 2013 with the possibility of an early finish for one or more. LCLS-II is included as a construction project in the FY 2013 request.	32,000

(Dollars in Thousands)

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Spallation Neutron Source Instrumentation I (SING I)	400	0	0
Spallation Neutron Source Instrumentation II (SING II)	17,000	11,500	0
SNS Power Upgrade (PUP)	2,000	0	0
Advanced Photon Source Upgrade (APS-U)	0	20,000	20,000
Linac Coherent Light Source-II (LCLS-II)	0	30,000	0[a]
NSLS-II Experimental Tools (NEXT)	0	12,000	12,000
Total, Major Items of Equipment	19,400	73,500	32,000

[a] LCLS-II is moved to line item construction in the FY 2013 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. These capabilities allow 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. These 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, but often overlooked, component in 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.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
FY 2011 Current	Funding supports the continued operations of the three electron beam microcharacterization centers, which are routinely available to users during normal operating hours. One key emphasis is on developing in situ techniques to characterize materials and correlate their microstructure with their mechanical and electrochemical behaviors. The accelerator physics and detector research supports development of high-current, high-gradient superconducting accelerating structures that design and test of radio frequency injectors capable of operating at high frequencies and delivering small-area beams, required by future light sources; studies of properties of cathode materials and factors that limit cathode lifetime; and several detector developments, from silicon to germanium and from stripline to 3-D detectors that emphasize high throughput and precision.	30,928
FY 2012 Enacted	In FY 2012, funding is provided to support operations of the three electron beam microcharacterization centers and their corresponding user programs. FY 2012 funding is below the optimal level with likely impact on machine maintenance and user support. Triennial reviews of centers will be conducted in FY 2012 to assess the facility performance, user operations, and the scientific output and impact. Accelerator physics and detector research will continue to be supported at a reduced level. Research in developing superconducting accelerating cavities and cathode development will be reduced. Support will be continued for the development of “smart” detectors, with concurrent signal processing capabilities, and solid state detectors optimized for next generation soft x-rays sources.	24,545

Fiscal Year	Activity	Funding ($000)
FY 2013 Request	Funding will be provided to support optimal operations of the three electron beam microcharacterization centers. The emphasis will be on maintaining a robust user program at the three user facilities. The outcomes of the FY 2012 triennial reviews will be used to inform funding decisions and guide program development at the three centers. The accelerator physics and detector research will 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.	27,000

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Electron-Beam Microcharacterization	11,587	11,000	12,000
Accelerator and Detector Research	19,341	13,545	15,000
Total, Research	30,928	24,545	27,000

Construction
Funding Profile by Activity

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Linac Coherent Light Source-II (LCLS-II), SLAC	0	0	63,500
National Synchrotron Light Source-II (NSLS-II), BNL	151,297	151,400	47,203
Total, Construction	151,297	151,400	110,703

Overview

Experiments in support of basic research require construction of state-of-the-art facilities and/or that existing facilities be upgraded to meet unique research requirements. Reactors, x-ray light sources, and pulsed neutron sources are among the expensive, but necessary, facilities required to support critical DOE science missions.

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)—continue the tradition of BES and SC providing the most advanced scientific user facilities for the Nation's research community in the most cost effective way. All BES construction projects are conceived and planned with the broad user community and, during construction, are executed on schedule and within cost. Furthermore, the construction projects all adhere to the highest standards of safety. These facilities provide the research community with the tools to fabricate, characterize, and develop new materials and chemical processes to advance basic and applied research across the full range of scientific and technological endeavor, including chemistry, physics, earth science, materials science, environmental science, biology, and biomedical science.

Performance will be measured by meeting the cost and schedule within 10% of the performance baseline established at Critical Decision 2, Approve Performance Baseline, and reproduced in the construction project data sheet.

Explanation of Funding Changes

	(Dollars in Thousands)		
	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Linac Coherent Light Source-II (LCLS-II)	0	63,500	+63,500
Funding is provided for PED and civil construction. LCLS-II was funded as a major item of equipment in FY 2012.			
National Synchrotron Light Source-II (NSLS-II)	151,400	47,203	-104,197
Funding for the civil construction will be ramped down, as scheduled.			
Total, Construction	151,400	110,703	-40,697

Supporting Information

Operating Expenses, Capital Equipment and Construction Summary

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Operating Expenses	1,366,819	1,447,493	1,603,205
Capital Equipment	89,765	73,500	58,000
General Plant Projects	11,375	200	7,315
Accelerator Improvement Projects	19,255	15,500	20,369
Construction	151,297	151,400	110,703
Total, Basic Energy Sciences	1,638,511	1,688,093	1,799,592

Funding Summary

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Research	691,736	682,026	771,282
Scientific User Facilities Operations	767,963	730,568	809,994
Major Items of Equipment	19,400	73,500	32,000
Construction Projects (includes OPC)	152,797	159,100	135,103
Other	6,615	42,899	51,213
Total, Basic Energy Sciences	1,638,511	1,688,093	1,799,592

Scientific User Facility Operations

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Synchrotron Radiation Light Source User Facilities			
Advanced Light Source, LBNL	59,600	62,000	70,000
Advanced Photon Source, ANL	137,175	123,000	134,800
National Synchrotron Light Source, BNL	41,500	36,000	39,500
National Synchrotron Light Source-II, BNL	0	0	22,000
Stanford Synchrotron Radiation Lightsource, SLAC	34,950	34,000	42,000
Linac Coherent Light Source (LCLS), SLAC	131,000	124,000	130,500
Total, Light Sources User Facilities	404,225	379,000	438,800

(Dollars in Thousands)

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
High-Flux Neutron Source User Facilities			
Spallation Neutron Source, ORNL	181,300	180,568	187,194
High Flux Isotope Reactor, ORNL	60,200	58,000	60,000
Intense Pulsed Neutron Source, ANL	3,000	0	0
Lujan Neutron Scattering Center, LANL	11,350	10,500	10,500
Total, Neutron Source User Facilities	255,850	249,068	257,694
Nanoscale Science Research Center User Facilities			
Center for Nanoscale Materials, ANL	22,047	20,500	22,700
Center for Functional Nanomaterials, BNL	20,471	20,000	22,700
Molecular Foundry, LBNL	22,313	20,500	22,700
Center for Nanophase Materials Sciences, ORNL	21,758	20,500	22,700
Center for Integrated Nanotechnologies, SNL/LANL	21,299	21,000	22,700
Total, Nanoscale Science Research Center User Facilities	107,888	102,500	113,500
Total, Scientific User Facility Operations	767,963	730,568	809,994

Facilities Users and Hours

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Advanced Light Source			
Achieved Operating Hours	4,916	N/A	N/A
Planned Operating Hours	4,700	4,800	5,200
Optimal Hours	5,600	5,600	5,600
Percent of Optimal Hours	88%	86%	93%
Unscheduled Downtime	<10%	<10%	<10%
Number of Users	1,931	1,900	2,100
Advanced Photon Source			
Achieved Operating Hours	4,906	N/A	N/A
Planned Operating Hours	5,000	5,000	4,800
Optimal Hours	5,000	5,000	5,000
Percent of Optimal Hours	98%	100%	96%
Unscheduled Downtime	<10%	<10%	<10%
Number of Users	3,986	3,800	3,700

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
National Synchrotron Light Source			
Achieved Operating Hours	5,885	N/A	N/A
Planned Operating Hours	5,400	4,800	5,300
Optimal Hours	5,400	5,400	5,400
Percent of Optimal Hours	109%	89%	98%
Unscheduled Downtime	<10%	<10%	<10%
Number of Users	2,313	2,000	2,200
Stanford Synchrotron Radiation Lightsource			
Achieved Operating Hours	4,775	N/A	N/A
Planned Operating Hours	4,900	5,200	5,200
Optimal Hours	5,400	5,400	5,400
Percent of Optimal Hours	88%	96%	96%
Unscheduled Downtime	<10%	<10%	<10%
Number of Users	1,515	1,500	1,500
Linac Coherent Light Source			
Achieved Operating Hours	3,925	N/A	N/A
Planned Operating Hours	4,100	4,300	4,200
Optimal Hours	4,500	4,500	4,300
Percent of Optimal Hours	87%	96%	98%
Unscheduled Downtime	<10%	<10%	<10%
Number of Users	516	500	450
High Flux Isotope Reactor			
Achieved Operating Hours	4,268	N/A	N/A
Planned Operating Hours	4,000	3,500	4,300
Optimal Hours	4,500	4,500	4,500
Percent of Optimal Hours	95%	78%	96%
Unscheduled Downtime	<10%	<10%	<10%
Number of Users	477	340	450

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Lujan Neutron Scattering Center			
Achieved Operating Hours	2,691	N/A	N/A
Planned Operating Hours	3,000	3,000	3,000
Optimal Hours	3,600	3,600	3,600
Percent of Optimal Hours	75%	83%	83%
Unscheduled Downtime	<10%	<10%	<10%
Number of Users	308	300	300
Spallation Neutron Source			
Achieved Operating Hours	5,000	N/A	N/A
Planned Operating Hours	4,900	4,500	4,600
Optimal Hours	4,900	4,900	4,900
Percent of Optimal Hours	102%	92%	94%
Unscheduled Downtime	<10%	<10%	<10%
Number of Users	890	780	830
Center for Nanoscale Materials[a]			
Number of Users	368	350	350
Center for Functional Nanomaterials[a]			
Number of Users	363	340	350
Molecular Foundry[a]			
Number of Users	327	300	350
Center for Nanophase Materials Sciences[a]			
Number of Users	374	350	350
Center for Integrated Nanotechnologies[a]			
Number of Users	348	340	350

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

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Total, All Facilities			
Achieved Operating Hours	36,366	N/A	N/A
Planned Operating Hours	36,000	35,100	36,600
Optimal Hours	38,900	38,900	38,700
Percent of Optimal Hours	96%	92%	96%
Unscheduled Downtime	<10%	<10%	<10%
Number of Users	13,716	12,800	13,280

Major Items of Equipment

(Dollars in Thousands)

	Prior Years	FY 2011 Current	FY 2012 Enacted	FY 2013 Request	Outyears	Total	Completion
Spallation Neutron Source Instrumentation-I, ORNL (TEC/TPC)	68,100	400	0	0	0	68,500	4Q FY 2011
Spallation Neutron Source Instrumentation-II, ORNL (TEC/TPC)	31,500	17,000	11,500	0	0	60,000	4Q FY 2014
SNS Power Upgrade Project , ORNL (TEC/TPC)	2,000	2,000	0	0	0	N/A[a]	N/A
Advanced Photon Source Upgrade (APS-U), ANL (TEC/TPC)	0	0	20,000	20,000	348,500	388,500	3Q FY 2020
Linac Coherent Light Source-II (LCLS-II), SLAC (TEC/TPC)	0	0	30,000	0[b]	0[b]	N/A[b]	N/A
NSLS-II Experimental Tools (NEXT), BNL (TEC/TPC)	0	0	12,000	12,000	66,000	90,000	4Q FY 2017
Total, Major Items of Equipment (TEC/TPC)		19,400	73,500	32,000			

[a] Project is terminated.

[b] LCLS-II is requested as a line item construction project in FY 2013. The TEC/TPC totals under construction include the FY 2012 funding that was requested as an MIE.

Construction Projects

(Dollars in Thousands)

	Prior Years	FY 2011 Current	FY 2012 Enacted	FY 2013 Request	Outyears	Total	Completion
13-SC-10, Linac Coherent Light Source-II (LCLS-II), SLAC							
TEC	0	0	0[a]	63,500	299,500	385,000[a]	4Q FY 2019[b]
OPC	1,126	9,474	0[a]	0	1,400	20,000[a]	
TPC	1,126	9,474	0[a]	63,500	300,900	405,000[a]	
07-SC-06, National Synchrotron Light Source-II, BNL							
TEC	415,000	151,297	151,400	47,203	26,300	791,200	3Q FY 2015
OPC	59,800	1,500	7,700	24,400	27,400	120,800	
TPC	474,800	152,797	159,100	71,603	53,700	912,000	
Total, Construction							
TEC		151,297	151,400	110,703			
OPC		10,974	7,700	24,400			
TPC		162,271	159,100	135,103			

Scientific Employment

	FY 2011 Actual	FY 2012 Estimate	FY 2013 Estimate
# of University Grants	1,100	1,060	1,170
Average Size per year	230,000	230,000	230,000
# Permanent Ph.D's (FTEs)	4,860	4,660	5,260
# Postdoctoral Associates (FTEs)	1,360	1,310	1,480
# Graduate Students (FTEs)	2,140	2,060	2,330

[a] $30,000,000 was requested 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).
[b] Estimate Only. Project has not been baselined.

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

1. Significant Changes

This project data sheet is the first submitted for Linac Coherent Light Source-II (LCLS-II) as a line item construction project. LCLS-II was proposed as a Major Item of Equipment (MIE) project in the FY 2012 Budget Request to Congress. However, as part of the conceptual design for CD-1, an alternatives analysis identified another option for the project that better meets SC mission objectives. This alternative requires extensive conventional construction activities, which are not suitable for an MIE project. As a result, the FY 2013 request proposes to convert the LCLS-II project into a line item construction project. FY 2012 funding will be used for design, in-house fabrication, long lead procurement, construction of an annex building, exploration and design of the two-tunnel option, and project management.

The most recent DOE O 413.3B approved Critical Decision, CD-1 (Approve Alternative Selection and Cost Range), was approved on October 14, 2011. The estimated 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. SC's Office of Project Assessment (OPA) reviewed the project request for CD-3A (Approve Long-Lead Procurements) on December 6–7, 2011, and the review recommended approval.

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

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

	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	4QFY2016[a]	1QFY2013[a]	3QFY2012[a]	3QFY2013[a]	4QFY2019[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[b]	367,000[b]	385,000[b]	20,000[b]	0	20,000[b]	405,000[b c]

[a] This project is pre-CD-2; the estimated schedule is preliminary. Construction funds 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 capacity of the existing Linac Coherent Light Source Facility, which provides coherent laser-like radiation in the 500–9,000 eV photon energy range, 10 billion times greater in peak brightness than any existing x-ray light source. This advance in brightness is similar to that of a synchrotron over a 1960s laboratory x-ray tube. Synchrotrons revolutionized science across disciplines ranging from atomic physics to structural biology. Advances from the LCLS are expected to be equally dramatic. The LCLS facility has convincingly demonstrated that it is a unique tool for transformational science. It has exceeded its initial performance goals in the 1.5–15 Angstrom range and the extraordinary high-brightness x-rays are being utilized on an initial set of scientific problems. It is the world's first such facility.

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 facility 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 B-Factory. 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.

Funding for conceptual design in FY 2011 supported the creation of a facility concept which has been reviewed and approved by DOE. The project will initiate engineering design and long lead procurements in FY 2012. FY 2013 funding will continue long lead procurements, design, and start of construction.

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 upgrade. 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

5. Financial Schedule

	(Dollars in Thousands)		
	Appropriations	Obligations	Costs
Total Estimated Cost (TEC)			
PED			
FY 2012	2,000[a]	2,000	1,800
FY 2013	5,000	5,000	5,100
FY 2014	4,000	4,000	4,000
FY 2015	4,000	4,000	4,000
FY 2016	3,000	3,000	3,100
Total, PED	18,000[b]	18,000[b]	18,000[b]

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

(Dollars in Thousands)

	Appropriations	Obligations	Costs
Construction			
FY 2012	20,000[a]	20,000	14,200
FY 2013	58,500	58,500	58,050
FY 2014	76,300	76,300	75,200
FY 2015	90,000	90,000	91,400
FY 2016	102,300	102,300	90,800
FY 2017	19,900	19,900	32,150
FY 2018	0	0	5,200
Total, Construction	367,000[b]	367,000[b]	367,000[b]
TEC			
FY 2012	22,000[a]	22,000	16,000
FY 2013	63,500	63,500	63,150
FY 2014	80,300	80,300	79,200
FY 2015	94,000	94,000	95,400
FY 2016	105,300	105,300	93,900
FY 2017	19,900	19,900	32,150
FY 2018	0	0	5,200
Total, TEC[b]	385,000[b]	385,000[b]	385,000[b]

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

[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.

	(Dollars in Thousands)		
	Appropriations	Obligations	Costs
Other Project Cost (OPC)			
OPC except D&D			
FY 2010	1,126	1,126	1,126
FY 2011	9,474	9,474	6,799
FY 2012	8,000[a]	8,000	9,875
FY 2013	0	0	800
FY 2014	700	700	500
FY 2015	0	0	200
FY 2016	700	700	500
FY 2017	0	0	200
Total, OPC	20,000[b]	20,000[b]	20,000[b]
Total Project Cost (TPC)			
FY 2010	1,126	1,126	1,126
FY 2011	9,474	9,474	6,799
FY 2012	30,000	30,000	25,875
FY 2013	63,500	63,500	63,950
FY 2014	81,000	81,000	79,700
FY 2015	94,000	94,000	95,600
FY 2016	106,000	106,000	94,400
FY 2017	19,900	19,900	32,350
FY 2018	0	0	5,200
Total, TPC[b]	405,000	405,000	405,000

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

[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.

6. Details of Project Cost Estimate

(Dollars in Thousands)

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

Request Year		(Dollars in Thousands) Prior Years	FY 2012	FY 2013	FY 2014	FY 2015	FY2016	FY2017	Total
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[a]	94,000[a]	106,000[a]	19,900[a]	405,000[a]

8. Related Operations and Maintenance Funding Requirements

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

9. Required D&D Information

New construction will be offset by 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 (DE-AC02-76-SF00515).

A Conceptual Design Report (CDR) 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 LCLS-II 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 completed by SLAC or LBNL staff. Technical equipment will either be fabricated in-house or contracted 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. It is anticipated that the conventional construction design will be contracted to an experienced Architect/Engineering (A/E) firm to perform Title I and II design. An experienced General Contractor will be hired to carry out conventional facilities construction.

All contracts will be competitively bid and awarded based on best value to the government.

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

[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.

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

1. 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. The overall project is approximately 67% complete with cumulative project Cost Performance Index (CPI) and Schedule Performance Index (SPI) at the end of November 2011 at 1.01 and 0.96 respectively.

The Federal Project Director is certified at level 4.

This PDS is an update of the FY 2012 PDS.

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

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

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

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 400 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 2011, the project is 69.0% complete. The cumulative cost and schedule performance indices are 1.01 and 0.96 respectively, both well within the BES performance goal of 0.90 to 1.10. The project is expected to take beneficial occupancy of pentant 5, the final pentant in the Ring Building, in January 2012. Installation of the accelerator systems equipment has started. Construction of the Lab Office Buildings (LOBs) is making excellent progress with the erection of the structural steel for LOB 5 having begun in November 2011. Conventional construction is on track to finish the ring building by April 2012 and the Lab Office Building scope by 1st quarter FY 2013. Installation for the Linac components started in September 2011 and is expected to be complete in December 2012. The start of Linac testing and commissioning with beam is anticipated in February 2012. The first container of booster ring components was shipped in November 2011. Installation, test and commission of technical systems will continue through FY 2012 and into FY 2013. The target date for the start of commissioning for the Storage Ring is the third quarter of FY 2013. The target early finish date remains June 2014 with CD-4 in June 2015.

During FY 2013, NSLS-II will continue the fabrication/procurement of accelerator systems components, beamline components and other support system components. The project will continue with the installation of accelerator components, most notably the ring girders/magnets, continue testing of components as they are installed, and will begin commissioning various parts of the accelerator systems. Construction of conventional facilities should be complete by early FY 2013. The FY 2013 funds are requested for contingency.

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

5. Financial Schedule

(Dollars in Thousands)

	Appropriations	Obligations	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	162,288
FY 2012	151,400	151,400	22,822	134,675
FY 2013	47,203	47,203	2,681	125,825
FY 2014	26,300	26,300	0	41,230
FY 2015	0	0	0	8,264
Total, Construction	731,200	731,200	150,000	581,200

(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	162,574
FY 2012	151,400	151,400	22,822	134,675
FY 2013	47,203	47,203	2,681	125,825
FY 2014	26,300	26,300	0	41,230
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	9,521
FY 2013	24,400	24,400	0	24,000
FY 2014	22,400	22,400	0	22,400
FY 2015	5,000	5,000	0	6,424
Total, OPC	120,800	120,800	0	120,800

(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	167,149
FY 2012	159,100	159,100	22,822	144,196
FY 2013	71,603	71,603	2,681	149,825
FY 2014	48,700	48,700	0	63,630
FY 2015	5,000	5,000	0	14,688
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)			
Design (PED)			
Design	60,000	60,000	49,000
Contingency	0	0	11,000
Total, PED	60,000	60,000	60,000

(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	608,961	567,885	518,381
Contingency	81,417	122,493	171,997
Total, Construction	731,200	731,200	731,200
Total, TEC	791,200	791,200	791,200
Contingency, TEC	81,417	122,493	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	50,200	50,200	50,200
Contingency	10,000	10,000	10,000
Total, OPC	120,800	120,800	120,800
Contingency, OPC	10,000	10,000	10,000
Total, TPC	912,000	912,000	912,000
Total, Contingency	91,417	132,493	192,997

7. Funding Profile History

(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.

(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 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

8. Related Operations and Maintenance Funding Requirements

Beneficial occupancy of the experimental floor:	4Q FY 2012
Expected useful life (number of years):	25
Expected future start of D&D of this capital asset (fiscal quarter):	N/A

(Related Funding Requirements)

(Dollars in Thousands)

	Annual Costs		Life cycle costs	
	Current Estimate	Prior Estimate	Current Estimate	Prior 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

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

9. Required D&D Information

	Square Feet
Area of new construction:	Approximately 400,000
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:	NA (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 were eliminated in FY 2006 at MIT and ETTP.

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 and consistent with the general expectation of the responsibilities of DOE M&O contractors.

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) contract was placed on a firm-fixed-price basis for the Final (Title II) Design and (Title III) construction support services. The general construction contract 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.

Biological and Environmental Research
Funding Profile by Subprogram and Activity

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Biological Systems Science			
Genomic Science			
Foundational Genomics Research	39,260	63,111	67,292
Genomics Analysis and Validation	10,000	10,000	10,000
Metabolic Synthesis and Conversion	39,912	19,462	19,462
Computational Biosciences	12,683	16,395	16,395
Bioenergy Research Centers	75,000	75,000	75,000
Total, Genomic Science	176,855	183,968	188,149
Radiological Sciences			
Radiochemistry and Imaging Instrumentation	17,540	19,410	17,540
Radiobiology	23,926	15,528	10,620
Total, Radiological Sciences	41,466	34,938	28,160
Ethical, Legal, and Societal Issues	1,000	0	0
Medical Applications	4,000	0	0
Biological Systems Facilities and Infrastructure			
Structural Biology Infrastructure	15,765	14,895	14,895
Joint Genome Institute	68,932	68,500	69,187
Total, Biological Systems Facilities and Infrastructure	84,697	83,395	84,082
SBIR/STTR	0	9,184	9,382
Total, Biological Systems Science	308,018	311,485	309,773
Climate and Environmental Sciences			
Atmospheric System Research	27,822	26,392	26,392
Environmental System Science			
Terrestrial Ecosystem Science	28,727	40,274	51,957
Terrestrial Carbon Sequestration Research	2,966	0	0
Subsurface Biogeochemical Research	48,838	27,380	27,380
Total, Environmental System Science	80,531	67,654	79,337

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Climate and Earth System Modeling			
Regional and Global Climate Modeling	31,273	28,659	32,964
Earth System Modeling	35,321	35,569	35,633
Integrated Assessment	11,258	9,853	9,853
Total, Climate and Earth System Modeling	77,852	74,081	78,450
Climate and Environmental Facilities and Infrastructure			
Atmospheric Radiation Measurement Climate Research Facility	45,770	67,977	70,574
Environmental Molecular Sciences Laboratory	51,340	50,324	47,671
Data Management	2,963	2,773	2,773
General Purpose Equipment (GPE)	250	500	500
General Plant Projects (GPP)	700	500	500
Total, Climate and Environmental Facilities and Infrastructure	101,023	122,074	122,018
SBIR/STTR	0	7,871	9,377
Total, Climate and Environmental Sciences	287,228	298,072	315,574
Total, Biological and Environmental Research	595,246[a]	609,557[b]	625,347

[a] Total is reduced by $16,577,000: $14,801,000 of which was transferred to the Small Business Innovation and Research (SBIR) program and $1,776,000 of which was transferred to the Small Business Technology Transfer (STTR) program.
[b] The FY 2012 appropriation is reduced by $2,266,000 for the Biological and Environmental Research Program share of the DOE-wide $73,300,000 rescission for contractor pay freeze savings. The FY 2013 budget request reflects the FY 2013 impact of the contractor pay freeze.

Public Law Authorizations

Public Law 95–91, “Department of Energy Organization Act”, 1977
Public Law 109–58, “Energy Policy Act of 2005”
Public Law 110–69, “America COMPETES Act of 2007”
Public Law 111–358, “America COMPETES Act of 2010”

Overview and Benefits

The Biological and Environmental Research (BER) program supports fundamental research and scientific user facilities to address diverse and critical global challenges. The program seeks to understand how genomic information is translated to functional capabilities, enabling more confident redesign of microbes and plants for sustainable biofuel production, improved carbon storage, or contaminant bioremediation. BER research advances understanding of the roles of Earth’s biogeochemical systems (the atmosphere, land, oceans, sea ice, and subsurface) in determining climate so we can predict climate decades or centuries into the future, information needed to plan for future energy and resource needs. Solutions to these challenges are driven by a foundation of scientific knowledge and inquiry in atmospheric chemistry and physics, ecology, biology, and biogeochemistry.

BER research uncovers nature’s secrets from the diversity of microbes and plants to understand how biological systems work, how they interact with each other, and how they can be manipulated to harness their processes and products. By starting with the potential encoded by organisms’ genomes, BER-funded scientists seek to define the principles that guide the translation of the genetic code into functional proteins and the metabolic/regulatory networks underlying the systems biology of plants and microbes as they respond to and modify their environments. BER integrates discovery- and hypothesis-driven science, technology development, and foundational genomics research into predictive models of biological function for DOE mission solutions.

BER plays a unique and vital role in supporting research on atmospheric processes, climate change modeling, interactions between ecosystems and greenhouse gases (especially carbon dioxide [CO_2]), and analysis of impacts and interdependencies of climatic change with energy production and use. Understanding the Earth's radiant energy balance associated with clouds, aerosols, and atmospheric greenhouse gases represent the largest uncertainty in determining the rate of global climate change. BER supports research on the factors determining this balance—the role of different types of clouds, atmospheric particles, and greenhouse gases. BER also supports research to understand the impacts of climatic change—warmer temperatures, changes in precipitation, increased levels of greenhouse gases, changing distributions of weather extremes—on different ecosystems such as forests, grasslands, and farmland. Finally, BER research seeks understanding of the critical role that biogeochemical processes play in controlling the cycling and mobility of materials in the Earth's subsurface and across key surface-subsurface interfaces in the environment.

BER's scientific impact has been transformative. In 1986, the Human Genome Project gave birth to modern biotechnology and genomics-based systems biology. Today, with its Genomic Sciences Program and the DOE Joint Genome Institute (JGI), BER researchers are using powerful tools of plant and microbial systems biology to pursue breakthroughs needed to develop cost-effective cellulosic biofuels. Our three DOE Bioenergy Research Centers lead the world in fundamental biofuels research.

Since the 1950s, BER has been a critical contributor to climate science research in the U.S., beginning with studies of atmospheric circulation—the forerunners of climate models. Today, BER supports the Community Earth System Model, a leading U.S. climate model, and addresses two of the most critical areas of uncertainty in contemporary climate science—the impact of clouds and aerosols—through support of the Atmospheric Radiation Measurement Climate Research Facility, which is used by hundreds of scientists worldwide.

Through partnership with the Advanced Scientific Computing Research (ASCR) program, BER leverages DOE's high-performance computational modeling, simulation, and data capabilities to address grand challenges in climate and earth system modeling, environmental modeling, and systems biology.

BER pioneered the frontier of subsurface science, discovering novel microorganisms and understanding biogeochemical processes, including the fate of subsurface contaminants. BER's Environmental Molecular Sciences Laboratory (EMSL) at the Pacific Northwest National Laboratory (PNNL) provides powerful suites of instruments and computers to characterize biological organisms and molecules.

Basic and Applied R&D Coordination

BER research underpins the needs of DOE's energy and environmental missions. Fundamental research on microbes and plants to understand the genetic and biochemical mechanisms that control growth, development, and metabolism provides knowledge needed by DOE's Office of Energy Efficiency and Renewable Energy and the U.S. Department of Agriculture to develop new bioenergy crops and improved biofuel production processes that are cost effective and sustainable.

BER research on the transport and transformation of subsurface contaminants provides knowledge needed by DOE's Office of Environmental Management (EM) to develop new strategies for the remediation of weapons-related contaminants at DOE sites and to develop advanced monitoring tools and strategies for use by DOE's Office of Legacy Management. EM's Advanced Simulation Capability for Environmental Management modeling framework will enable better translation of BER fundamental science on subsurface processes to the EM community.

Finally, BER research to understand and predict future changes in the Earth's climate system is needed by DOE's Office of Policy and International Affairs as it develops strategies for our Nation's future energy needs and control of greenhouse gas emissions. The BER Integrated Assessment models continue to be important tools that link climate predictions to evaluations of new energy policies on greenhouse gas emissions as well as to help guide the design criteria for next generation energy infrastructures.

In general, BER coordinates with DOE's applied technology programs through regular joint program manager meetings, and by participating in their internal program reviews, by participating in joint contractor meetings, and by conducting joint technical workshops.

Program Accomplishments and Milestone

Engineering microbes to directly convert plant material into different "drop-in" biofuels. Bioenergy Research Center scientists at the BioEnergy Science Center and the Joint BioEnergy Institute have metabolically engineered a war chest of different cellulose-degrading microbes to convert inedible plant material directly into different drop-in automotive, diesel, and jet biofuels. This work creates advances in consolidated biomass processing to produce a diversity of biofuels compatible with existing engines.

Assessing carbon impacts of land-use choices for bioenergy crops. Scientists at the Great Lakes Bioenergy Research Center have analyzed impacts of converting former croplands, now existing as grasslands, to various bioenergy production scenarios. Their results show that crop selection and soil management practices have a strong impact on greenhouse gas emission and carbon storage and will inform development of sustainable land management strategies for producing bioenergy crop systems.

Discovering new enzymes from microbes in a cow rumen digesting switchgrass. Scientists at the Joint Genome Institute analyzed the metagenome of the microbes in a cow rumen digesting the bioenergy crop switchgrass, enabling future discoveries of enzymes to break down plant material into simple sugars that could be converted into renewable biofuels.

ARM data improves climate models. Using a ten-year data set that integrates measurements from multiple Atmospheric Radiation Measurement Climate Research Facility (ARM) instruments, scientists have improved our ability to quantify the impact of clouds on climate model uncertainties. This joint effort between the ARMs and the BER Climate and Earth System Modeling activities improves our confidence in future projections of climate models.

EMSL capabilities lead to new catalyst for ethanol conversion. Using microstructure characterization instruments at the Environmental Molecular Sciences Laboratory (EMSL), scientists identified a new catalyst that converts ethanol, including bioethanol, to isobutene in a single step. Isobutene is a versatile feedstock chemical for jet fuel, tire rubber, solvents, gasoline additives, and other applications.

Milestone	**Date**
Provide to Congress an evaluation of each Bioenergy Research Center, a comparison of each center's achievements with the Department's original targets, and the Department's subsequent recommendation for extension or conclusion of each center.	February 2012
Demonstrate coupled climate models at 20km resolution.	4th Qtr, FY 2012
The average achieved operation time of the BER scientific user facilities as a percentage of the total scheduled annual operating time is greater than 98%.	4th Qtr, FY 2012

Explanation of Changes

Biological and Environmental Research continues support for key core research areas and scientific user facilities in bioenergy, climate, and environmental research. Increased investments target the development of synthetic biology tools and technologies and integrative analysis of experimental datasets. Observational research increases to improve understanding of the priority climatic sensitive regions of the Arctic and tropics, and modeling efforts will shift their emphasis from global scale dynamics to higher resolution scale interactions for these priority regions.

Program Planning and Management

BER uses broad input from scientific workshops[a] and external reviews, including those performed by the National Academies, to identify current and future scientific and technical needs and challenges in current national and international research efforts. BER also receives advice from the Biological and Environmental Research Advisory Committee (BERAC) on the management of its research programs (through Committee of Visitor [COV] reviews), on the direction and focus of its research programs, and on strategies for long-term planning and development of its research activities.

[a] BER scientific workshop reports are available at http://science.energy.gov/ber/news-and-resources

In FY 2011, BERAC issued a report on an overall strategy to inform a long-term vision for BER. A key emphasis of the report was the identification of the greatest scientific challenges in biological, climate, and environmental systems science that BER should address in the long-term (20-year horizon) and how BER should be positioned to address those challenges; the continued or new fields of BER-relevant science that DOE will need to pursue to achieve its future mission challenges; and the future scientific and technical advances needed to underpin BER's complex systems science. The report, "Grand Challenges for Biological and Environmental Research: A Long-Term Vision" [a] identified grand challenges in complex systems and synthetic biology, climate modeling and climate-related ecosystem science, energy sustainability, computing, and education and workforce development.

BER supports research at universities, research institutes, private companies, and DOE national laboratories. All BER-supported research undergoes regular peer review and merit evaluation based on procedures established in 10 CFR 605 for the external grant program and using a similar process for research at the national laboratories. BERAC conducts COV reviews of the merit evaluation conducted by BER subprograms every three years. Results of these reviews and BER responses are posted online[a]. A COV was assembled in 2011 to review Biological System Science Division. Every three years, BER also conducts consolidated onsite merit, operational, management, and safety reviews of each of its user facilities. Results of these reviews are used to address management, scientific, operational, and safety deficiencies.

[a] http://science.energy.gov/ber/berac/reports/

The BER program is coordinated with activities of over 14 other federal organizations supporting or conducting complementary research. BER Climate Change Research is coordinated with the U.S. Global Change Research Program, an interagency program codified by Public Law 101-606 and involving other federal agencies and departments, and the U.S. Climate Change Technology Program.

Program Goals and Funding

Office of Science performance expectations (and therefore funding requests) are focused on four areas:

Research: Increase our understanding of and enable predictive control of phenomena in complex biological, climatic, and environmental systems sciences.

Facility Operations: Maximize the reliability, dependability, and availability of the SC scientific biological, climatic, and environmental user facilities.

Future Facilities: Build future and upgrade existing facilities and experimental capabilities to ensure the continuing value of the SC scientific user facilities. All construction projects and MIEs are within 10% of their specified cost and schedule baselines.

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	Facility Operations	Future Facilities	Scientific Workforce
Biological Systems Science	70%	30%	0%	0%
Climate and Environmental Sciences	60%	40%	0%	0%
Total, Biological and Environmental Research	65%	35%	0%	0%

Explanation of Funding and Program Changes

	(Dollars in Thousands)		
	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Biological Systems Science	311,485	309,773	-1,712
BER is increasing investment in the development of synthetic biology tools and biodesign technologies and integrative analysis of experimental genomic science datasets. The resulting new molecular-level insight into the design, function, and regulation of plants, microbes, and biological communities will contribute toward cost-effective production of next generation biofuels as a major secure national energy resource and the bioeconomy. Support is continued for core research in bioenergy and carbon cycling, including the DOE Bioenergy Research Centers. Radiological science research is decreased as funding for the activities on human nuclear medicine and exposure outcomes at Fukushima Daiichi are completed in FY 2012.			
Climate and Environmental Sciences	298,072	315,574	+17,502
BER observational efforts to describe the interrelationships between climate change in Arctic and tropical ecosystems, including aerosols and clouds, will increase, and modeling efforts will shift their emphasis from global scale dynamics to higher resolution scale interactions for regions that are of primary interest to both the scientific community and stakeholders. Subsurface Biogeochemical Research is reduced on contaminant mobility and on geologic barriers to groundwater contaminant transport.			
Total, Biological and Environmental Research	609,557	625,347	+15,790

Biological Systems Science
Funding Profile by Activity

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Genomic Science			
Foundational Genomics Research	39,260	63,111	67,292
Genomics Analysis and Validation	10,000	10,000	10,000
Metabolic Synthesis and Conversion	39,912	19,462	19,462
Computational Biosciences	12,683	16,395	16,395
Bioenergy Research Centers	75,000	75,000	75,000
Total, Genomic Science	176,855	183,968	188,149
Radiological Sciences			
Radiochemistry and Imaging Instrumentation	17,540	19,410	17,540
Radiobiology	23,926	15,528	10,620
Total, Radiological Sciences	41,466	34,938	28,160
Ethical, Legal, and Societal Issues (ELSI)	1,000	0	0
Medical Applications	4,000	0	0
Biological Systems Facilities and Infrastructure			
Structural Biology Infrastructure	15,765	14,895	14,895
Joint Genome Institute	68,932	68,500	69,187
Total, Biological Systems Facilities and Infrastructure	84,697	83,395	84,082
SBIR/STTR	0[a]	9,184	9,382
Total, Biological Systems Science	308,018	311,485	309,773

[a] In FY 2011, $7,791,000 and $935,000 were transferred to the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs, respectively. SBIR/STTR funding is set at 2.95% of non-capital funding in FY 2012 and 3.05% in FY 2013.

Overview

Biological Systems Science is unique in the U.S. science enterprise in integrating discovery- and hypothesis-driven science, technology development, and foundational research on plant and microbial systems. Systems biology is the multidisciplinary study of complex interactions specifying the function of entire biological systems—from single cells to multicellular organisms—rather than the study of individual components. The Biological Systems Science subprogram focuses on utilizing systems biology approaches to define the functional principles that drive living systems, from microbes and microbial communities to plants and other whole organisms.

Key questions that drive these studies include:

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

The approaches employed include genome sequencing, proteomics, metabolomics, structural biology, high-resolution imaging and characterization, and integration of information into predictive computational models of biological systems that can be tested and validated.

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

Explanation of Funding Changes

	(Dollars in Thousands)		
	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Genomic Science	183,968	188,149	+4,181
Genomic Science research remains a priority activity, with Foundational Genomics Research increasing for the development of synthetic biology tools and biodesign technologies for plant and microbial systems relevant to bioenergy production, carbon and nutrient cycling, and environmental change. Targeted research in Metabolic Synthesis and Conversion on cellulosic ethanol and biohydrogen decreases, as the DOE Bioenergy Research Centers continue to conduct research on advanced renewable biofuels. Computational Biosciences continues to enable the Systems Biology Knowledgebase tools and integrative analysis of plant and microbial functional genomics experimental datasets.			
Radiological Sciences	34,938	28,160	-6,778
Radionuclide imaging research for real-time visualization of dynamic biological processes in energy and environmentally-relevant contexts continues, while concluding training activities to transfer synthetic and instrumentation knowledge to the nuclear medicine research community. Research is specifically prioritized to enable mechanism-based models that incorporate both radiobiology and epidemiology, reducing activities in cell-to-cell communication, cell aging and senescence, and cell microenvironment. Funding for research informing the exposure outcomes of the Fukushima Daiichi nuclear reactor is completed in FY 2012.			
Biological Systems Facilities and Infrastructure	83,395	84,082	+687
Funding continues to support large-scale, complex genome sequencing and analysis at the Joint Genome Institute, with increasing emphasis on understanding comparative or community-scale plant and microbial genomics. Support continues for the development of instrumentation at SC's synchrotron light sources, neutron sources, and next-generation user facilities for analyzing biological structure-function relationships.			
SBIR/STTR	9,184	9,382	+198
SBIR/STTR funding levels are a set percent of overall research funding.			
Total, Biological Systems Science	311,485	309,773	-1,712

Genomic Science

Overview

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

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

This Systems Biology Knowledgebase is designed to be an integrated experimental framework for accessing, comparing, analyzing, modeling, and testing Genomic Science data. The first phase of the knowledgebase effort becomes fully operational in FY 2013 with the integration of plant and microbial experimental with genomic sequencing datasets.

The team-based multi-institutional Bioenergy Research Centers focus on innovative research to achieve the basic science breakthroughs needed to develop sustainable and effective methods of producing cellulosic biofuels.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
FY 2011 Current	Genomic Science activities supported comparative genomic analysis, functional annotation of genes, proteins, and metabolic or regulatory networks, and development of new multi-modal imaging instrumentation for dynamic characterization of biological processes in plants and microbes. The Bioenergy Research Centers performed multidisciplinary research on converting inedible plant biomass to advanced renewable biofuels. The Computational Bioscience activity established a Systems Biology Knowledgebase to develop capabilities for broad researcher access and integration of microbial and plant genomic datasets.	176,855
FY 2012 Enacted	Support continues for core research activities in plant and microbial systems-level functional genomics and for the Bioenergy Research Centers. Foundational Genomics Research supports the development of new synthetic molecular toolkits for understanding natural systems combined with computer-aided design testbeds for the construction of improved biological components, processes, and systems. These toolkits and testbeds will facilitate synthetic biology design engineering and prototyping of improved multi-component biological functional modules with applications in bioenergy production, environmental remediation, and carbon cycling. This new activity was informed by the report from the 2011 Biosystems Design Workshop[a].	183,968

[a] http://science.energy.gov/ber/news-and-resources/

Fiscal Year	Activity	Funding ($000)
	Computational Biosciences will further develop a Systems Biology Knowledgebase to integrate microbial community genomic, proteomic, and transcriptomic experimental data sets from research conducted at the DOE Bioenergy Research Centers, the Joint Genome Institute, and the Genomic Science supported activities. Synthetic biology research, including environmental, ethical, legal, and societal impacts, will be coordinated across the Federal Government. The increase will also support development of new methods for simulation of microbial metabolism and cellular regulation.	
FY 2013 Request	Investment in the development of synthetic biology tools and biodesign technologies and integrative analysis of experimental genomic science datasets will be increased. The resulting new molecular-level insight into the design, function, and regulation of plants, microbes, and biological communities will contribute to cost-effective production of next generation biofuels as a major secure national energy resource. The activity will continue to coordinate across the Federal Government on research on the environmental, ethical, legal, and societal impact of synthetic biology, especially to understand stability and containment of engineered genes in environmental settings. Support continues for core research activities in plant and microbial systems-level functional genomics and networks, with completion of Metabolic Synthesis and Conversion targeted research on cellulosic ethanol and biohydrogen. Based upon the successful outcome of a merit review conducted in FY 2012, the Bioenergy Research Centers will begin a renewal funding period in FY 2013, continuing research on advanced biofuels. Computational Biosciences supports the Systems Biology Knowledgebase effort to develop predictive simulation efforts in microbial community interactions.	188,149

(Dollars in Thousands)

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Foundational Genomics Research	39,260	63,111	67,292
Genomics Analysis and Validation	10,000	10,000	10,000
Metabolic Synthesis and Conversion	39,912	19,462	19,462
Computational Biosciences	12,683	16,395	16,395
Bioenergy Research Centers	75,000	75,000	75,000
Total, Genomic Science	176,855	183,968	188,149

Radiological Sciences

Overview

Radiological Sciences supports radionuclide synthesis and imaging research for real-time visualization of dynamic biological processes in energy and environmentally relevant contexts. The activity has significantly transitioned from its historical focus on nuclear medicine research and applications for health to focus on real-time, whole organism understanding of metabolic and signaling pathways in plants and nonmedical microbes. Radionuclide imaging continues to be a singular tool for studying living organisms in a manner that is quantitative, three dimensional, temporally dynamic, and non-perturbative of the natural biochemical processes. The instrumentation research focuses on improved metabolic imaging in the living systems, including plants and microbial-communities, relevant to biofuels production and bioremediation of interest to DOE. The activity also supports fundamental research on integrated gene function and response of biological organisms to low dose radiation exposure, through systems genetics analysis in model systems and epidemiological studies. This activity contributes a scientific foundation for informed decisions regarding remediation of contaminated DOE sites and for determining acceptable levels of human health protection, for both cleanup workers and the public, in the most cost-effective manner.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
FY 2011 Current	Research supported the development and use of innovative radiotracer chemistry and complementary radionuclide imaging instrumentation technologies for quantitative *in vivo* measurement of radiotracer concentration and site-specific chemical reactions. Research was initiated to examine epidemiological models for low dose radiation exposure.	41,466
FY 2012 Enacted	Core research activities in radiotracer synthetic chemistry and complementary imaging instrumentation continues; additional activity includes nuclear medicine research with human application as directed by Congress (in the FY 2012 Energy and Water Development Appropriations conference report [H. Rpt. 112-331]), and a report will be prepared for a strategy to continue this research through more appropriate federal agencies with health-focused missions. Research is completed for integrated training in radiotracer synthetic methodology and *in vivo* imaging and detection relevant to nuclear medicine applications. Funds support a limited number of systems genetic studies of integrated gene function and response to the environment, drawing on prior studies of specific gene targets and individual cellular response and focusing only at the tissue or whole organism level. H. Rpt. 112-331 directs continuation of research to help determine health risks from exposures to low levels of ionizing radiation, as well as studies of health impacts at and around the Fukushima Daiichi nuclear plant.	34,938
FY 2013 Request	Funding continues for core research activities in radiotracer synthetic chemistry for real-time visualization of dynamic biological processes in the energy and environmentally-relevant contexts. Funding is completed in FY 2012 for studies of DNA damage and repair in response to low dose radiation of specific gene targets in single cell culture models and for studies informing the exposure risks at the Fukushima Daiichi nuclear plant. Research will be completed for the development of a limited number of systems genetic reference mouse populations. Priority research begins to address integration of mechanism-based models that incorporate both radiobiology and epidemiology.	28,160

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Radiochemistry and Imaging Instrumentation	17,540	19,410	17,540
Radiobiology	23,926	15,528	10,620
Total, Radiological Sciences	41,466	34,938	28,160

Ethical, Legal, and Societal Issues

Overview

The activity addresses ethical, legal, and societal impacts for application of genomic research results in bioenergy, synthetic biology, and nanotechnology. Beginning in FY 2012, research related to the societal benefits and implications of DOE mission areas will be addressed within relevant Genomic Science programmatic activities. Beginning in FY 2013, 5% of funding for synthetic biology and biodesign activities in Foundational Genomics Research will be directed toward this research.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
FY 2011 Current	Funds supported the completion of individual studies on the societal impacts of synthetic biology and bioenergy.	1,000
FY 2012–2013	Activity is completed.	0

Medical Applications

Overview

This activity supports the design, fabrication, integration, and testing of a 240+ microelectrode visual prosthesis device (the artificial retina). DOE's role in this effort was completed in FY 2011.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
FY 2011 Current	BER research on the development of the components of an artificial retina was completed in FY 2010. In FY 2011, research was completed on the 240+ electrode artificial retina device integration and final testing and refinement of the assembled device for readiness to transition to pre-clinical testing.	4,000
FY 2012–2013	Activity is completed.	0

Biological Systems Science Facilities and Infrastructure

Overview

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

The JGI is developing aggressive new strategies for complex genome assembly using next-generation sequencing platforms and genomic analysis tools. The JGI also performs metagenome (genomes from multiple organisms) sequencing and analysis from environmental samples and is developing single cell sequencing techniques on hard-to-culture cells from environments relevant to DOE missions. Technological requirements are driven by the Bioenergy Research Centers and grand challenge proposals submitted by the broader scientific user community.

BER also supports development and use of specialized instrumentation for biology at the major DOE user facilities, such as the synchrotron light sources and neutron facilities. These research facilities enable science aimed at understanding the structure and properties of biological systems at resolution and scale not possible with instrumentation available in university, institute, or industrial laboratories. This information is critical in contributing to our understanding of the relationship between genome, biological structure, and function, leading to practical applications of this knowledge for energy and the environment.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
FY 2011 Current	The JGI provided access to the scientific user community and the DOE Bioenergy Research Centers to large-scale genome data acquisition and analysis. Support continued for research at established structural biology instrumentation at the synchrotron light sources and neutron facilities.	84,697
FY 2012 Enacted	JGI continues to provide access to the scientific user community and the DOE Bioenergy Research Centers for large-scale genome data acquisition and analysis. Funding supports a greater emphasis on metagenome expression and sequencing of environmental microbial communities or the plant-microbe rhizosphere, improved genome annotation, and functional analysis and verification of genome-scale models. JGI initiates new efforts to transform its capabilities and provide functional genomic interpretations of biological systems in large scale multi-disciplinary environmental and targeted systems biology studies while maintaining operating performance at 98% of scheduled operating time. Support continues for research at established structural biology instrumentation at the synchrotron light sources and neutron facilities, informed by the report of the 2011 workshop on "*Applications of new DOE National User Facilities in Biology*"[a].	83,395

[a] http://science.energy.gov/ber/news-and-resources/

Fiscal Year	Activity	Funding ($000)
FY 2013 Request	The JGI supports a greater emphasis on functional genomics analysis for plants and microbes combining massive sequencing capability with high performance computing for data management, integration, and analysis in conjunction with BER's Systems Biology Knowledgebase effort. JGI continues to utilize new technologies for higher-throughput genome analysis and integration with other proteomic and metabolomic datasets and develop new high-throughput sample processing to ease pre-sequencing sample preparation bottlenecks to large scale sequencing projects. JGI sequencing capabilities also support synthetic biology design efforts. Support continues to develop structural biology instrumentation and end stations and new research capabilities at the synchrotron light sources and neutron facilities.	84,082

(Dollars in Thousands)

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Structural Biology Infrastructure	15,765	14,895	14,895
Joint Genome Institute	68,932	68,500	69,187
Total, Biological Systems Facilities and Infrastructure	84,697	83,395	84,082

Climate and Environmental Sciences
Funding Schedule by Activity

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Atmospheric System Research	27,822	26,392	26,392
Environmental System Science			
Terrestrial Ecosystem Science	28,727	40,274	51,957
Terrestrial Carbon Sequestration Research	2,966	0	0
Subsurface Biogeochemical Research	48,838	27,380	27,380
Total, Environmental System Science	80,531	67,654	79,337
Climate and Earth System Modeling			
Regional and Global Climate Modeling	31,273	28,659	32,964
Earth System Modeling	35,321	35,569	35,633
Integrated Assessment	11,258	9,853	9,853
Total, Climate and Earth System Modeling	77,852	74,081	78,450
Climate and Environmental Facilities and Infrastructure			
Atmospheric Radiation Measurement (ARM) Climate Research Facility	45,770	67,977	70,574
Environmental Molecular Sciences Laboratory	51,340	50,324	47,671
Data Management	2,963	2,773	2,773
General Purpose Equipment (GPE)	250	500	500
General Plant Projects (GPP)	700	500	500
Total, Climate and Environmental Facilities and Infrastructure	101,023	122,074	122,018
SBIR/STTR	0[a]	7,871	9,377
Total, Climate and Environmental Sciences	287,228	298,072	315,574

[a] In FY 2011, $7,010,000 and $841,000 were transferred to the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs, respectively. SBIR/STTR funding is set at 2.95% of non-capital funding in FY 2012 and 3.05% in FY 2013.

Overview

The Climate and Environmental Sciences subprogram focuses on a predictive, systems-level understanding of the fundamental science associated with climate change and DOE's environmental challenges—both key to supporting DOE's science mission. The subprogram supports an integrated portfolio of research from molecular-level to field-scale studies with emphasis on multidisciplinary experimentation and use of advanced computer models. The science and research capabilities supported enable DOE leadership in climate-relevant atmospheric-process research and modeling, including clouds, aerosols, and the terrestrial carbon cycle; large-scale climate change modeling; experimental research on the effects of climate change on ecosystems; integrated analysis of climate change impacts; and advancing fundamental understanding of coupled physical, chemical, and biological processes controlling contaminant mobility in the environment. The Department will continue to advance the science necessary to further develop predictive climate and earth system models at the regional spatial scale and decadal to centennial time scales, involving close coordination with the U.S. Global Change Research Program and through the international science community.

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

Explanation of Funding Changes

(Dollars in Thousands)

	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Atmospheric System Research	26,392	26,392	0
Research continues on improved formulations for aerosols, clouds, and aerosol-cloud interactions in order to improve estimates of how these feedbacks have and will impact climate.			
Environmental System Science	67,654	79,337	+11,683
The activity will continue to support a next-generation ecosystem experiment, begun in 2012, focused on the relationship between climate change and Arctic permafrost ecosystems and will initiate a new activity exploring the relationship between climate and tropics ecology. Subsurface biogeochemical research continues to focus on environmental research across scales as a continuum of complex interdependent processes, while reducing emphasis on contaminant mobility and on geologic barriers to groundwater contaminant transport.			
Climate and Earth System Modeling	74,081	78,450	+4,369
Research increases to improve model resolution and enhance model validation and verification as well continue improving the efficiency of data management and analysis.			
Climate and Environmental Facilities and Infrastructure	122,074	122,018	-56
ARM will increase to fully operate the new mobile facility deployed at Oliktok, AK, and permanent site in the Azores, the first permanent midlatitude marine ARM Climate Research Facility site. The Environmental Molecular Sciences Laboratory will decrease as the funding is completed in FY 2012 for the High Magnetic Field Mass Spectrometer. EMSL operations will continue to support users on the advanced capabilities delivered through the Recovery Act.			

(Dollars in Thousands)

	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
SBIR/STTR	7,871	9,377	+1,506
SBIR/STTR funding is set as a percent of overall research funding. In FY 2012 the ARM Climate Research Facility and EMSL capital equipment funding is completed and operations funding increases.			
Total, Climate and Environmental Sciences	298,072	315,574	+17,502

Atmospheric System Research

Overview

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

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
FY 2011 Current	Research supported improved understanding and modeling the radiation balance from the surface of the Earth to the top of the atmosphere and how this balance is affected by clouds and aerosols. One focus was evaluation and updating of atmospheric process modules introduced into the Community Earth System Model in 2010.	27,822
FY 2012 Enacted	Research continues using data from the new instruments at the ARM sites to support research, specifically the development of three-dimensional representation of clouds in climate models. Research also continues on marine boundary layer clouds, Arctic clouds and their interactions with aerosols, and processes and atmospheric transformations involving biogenic aerosols.	26,392
FY 2013 Request	Continues process studies and modeling efforts on developing improved formulations for aerosols, clouds, and aerosol-cloud interactions in order to improve estimates of how these feedbacks have and will impact the climate. Specific focuses include Arctic and tropical aerosol-cloud-precipitation interactions, and high altitude (cirrus) clouds and their life cycles and impacts on radiation budget.	26,392

Environmental System Science

Overview

Environmental System Science supports research that provides scientific understanding of the effects of climate change on terrestrial ecosystems, the role of terrestrial ecosystems in global carbon cycling, and the role of subsurface biogeochemical processes determining flow and transport in the subsurface and how the subsurface and above ground environments interact.

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

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

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
FY 2011 Current	Continued research to understand and predict important potential effects of climate change and increasing atmospheric CO_2 concentration on mid-latitude and boreal/peatland ecosystems. Continued integrated, multi-disciplinary, multi-scale research to advance a predictive understanding of processes controlling the mobility of radionuclides and nutrients in the environment.	80,531
FY 2012 Enacted	Research continues to focus on potential effects of warming, changes in rainfall, and increasing concentrations of atmospheric CO_2 on terrestrial ecosystems and the terrestrial carbon cycle. A shift in emphasis focuses on a new next-generation ecosystem-climate change experiment to predict changes in Arctic permafrost. Research efforts continue to test and evaluate computer models describing subsurface mobility of radionuclides and nutrients. In addition, experimental research at the three Integrated Field Research Challenge (IFRC) sites will emphasize sites where there are biological and biogeochemical process controls over heavy metal and radionuclide flow and transport, reducing activities at two of the sites.	67,654
FY 2013 Request	Funding continues support for the Arctic Next Generation Ecosystem Experiment to improve the representation of the major carbon sinks associated with changes in Arctic permafrost ecosystems in Earth system and regional climate models. A second Next Generation Ecosystem Experiment (NGEE) will be initiated to address poorly understood ecosystem processes that govern biogenic aerosol emissions to the atmosphere. Focusing on one of the most climatically-sensitive tropical regions, the experiment will examine the role of rainfall stress on Amazonian ecosystems and the resulting shifts in released aerosols that serve as cloud condensation nuclei.	79,337

Fiscal Year	Activity	Funding ($000)
	Subsurface Biogeochemical Research continues support to advance the predictive understanding of processes controlling the mobility of radionuclides and nutrients in the environment, including field-based activities at one IFRC site. The focus of the multi-disciplinary field-based investigations will retain a focus to advance a science-based general modeling framework, based on a shift to larger system scales as recommended in the 2010 workshop report, "*Complex Systems Science for Subsurface Fate and Transport*"[a].	

(Dollars in Thousands)

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Terrestrial Ecosystem Science	28,727	40,274	51,957
Terrestrial Carbon Sequestration Research	2,966	0	0
Subsurface Biogeochemical Research	48,838	27,380	27,380
Total, Environmental System Science	80,531	67,654	79,337

[a] http://science.energy.gov/ber/news-and-resources/

Climate and Earth System Modeling

Overview

Climate and Earth System Modeling develops physical, chemical, and biological model components, including the interactions of human and natural earth systems, needed to simulate climate variability and change from decades to centuries at regional and global scales. The research specifically focuses on quantifying and reducing the uncertainties in earth system models. Priority model components include the ocean, sea-ice, land-ice, aerosols, atmospheric chemistry, terrestrial carbon cycling, and dynamical cores.

A unique objective of the BER Climate and Earth System Modeling investments is the study and modeling of both historical and current climate change, with an objective to validate and improve future climate projections based on the prediction successes using existing data testbeds. To rapidly and efficiently advance model capabilities, BER supports a unique and powerful inter-comparison resource for global climate model development, validation, diagnostics, and outputs, using all 23 of the world's leading climate models. This ensures BER can exploit the best available science and practice within each of the world's leading climate research programs. The BER-supported Community Earth System Model is designed by the research community with open access and broad use by climate researchers worldwide; this model provides a critical capacity for regional climate projections, including information on how the frequency of occurrence and intensity of storms, droughts, and heat waves will change as climate evolves. Demonstrating the critical linkages between DOE's climate modeling investments, the scientific priorities for improvement of the community model are based on the outputs of the intercomparison and validation resource. DOE has also provided computational power and expertise to the Earth System modeling community, through its internal partnership between BER and ASCR, innovating code design for optimal model computation on its petascale computers. Investments in the development of reliable climate modeling tools are essential for informing multibillion to trillion dollar investment decision-making processes for infrastructures associated with large-scale deployment of energy supply and transmission.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
FY 2011 Current	Research focused on incorporating and testing improved representations of specific processes and sub-systems within the coupled models. Efforts have focused on aerosols, convection, ice sheets, and land surface in the coupled climate models; water supply and demand and land use interactions in the integrated assessment models; and evaluations using innovative metrics that span a variety of climate time scales. Research to increase model resolution and computational performance was also conducted, as well as multi-scale process interactions and issues.	77,852
FY 2012 Enacted	Model enhancements will focus on adding additional representations of processes within the coupled models while improving understanding and representations of complex systems dynamics. For example, ice sheet and ocean models will be coupled in the Community Earth System Model to be capable of projecting sea-level rise, and systems dynamics will be explored within and among Earth system and integrated assessment models. Additional work will be centered on improving both the spatial and temporal resolutions required for DOE mission-focused needs. This includes the development of a variable grid coupled climate model, able to produce predictions at 20 km resolution by the 4th quarter of FY 2012. Tools for the dissemination of climate model output in support of the Intergovernmental Panel on Climate Change (IPCC) Assessment Report 5 (AR 5) will be implemented.	74,081

Fiscal Year	Activity	Funding ($000)
FY 2013 Request	Research will focus on the development of an enhanced validation and verification capability to compare models and measurements with common framework and sophisticated software tools. A framework to use ARM measurements to validate the clouds and terrestrial carbon measurements to validate the land model will be included in this toolbox. Research will be increased to enhance resolution of climate models operating on regional scales, and to the expand model diagnostics, databases, and intercomparison studies. Funding will be provided to augment the data and diagnostic technical and analysis capabilities within the national laboratories, so that climate projections carried out in support of the IPCC AR5.	78,450

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Regional and Global Climate Modeling	31,273	28,659	32,964
Earth System Modeling	35,321	35,569	35,633
Integrated Assessment	11,258	9,853	9,853
Total, Climate and Earth System Modeling	77,852	74,081	78,450

Climate and Environmental Facilities and Infrastructure

Overview

Climate and Environmental Facilities and Infrastructure includes two scientific user facilities, climate data management for the climate science community, and general purpose equipment and plant projects for the Oak Ridge Institute for Science and Education. Two scientific user facilities—the Atmospheric Radiation Measurement Climate Research Facility (ARM) and the Environmental Molecular Sciences Laboratory (EMSL)—provide the broad scientific community with technical capabilities, scientific expertise, and unique information to facilitate science in areas integral to the DOE/BER mission.

ARM is a multi-platform national scientific user facility, providing the world's most comprehensive continuous field measurements of climate data to promote the advancement of atmospheric process understanding and climate models through precise observations of atmospheric phenomena. ARM currently contains three fixed long-term measurement facility sites (in Oklahoma, Alaska, and the western Pacific), two mobile facilities, and an airborne research capability that operates at sites selected by the scientific community. The ARM permanent sites and mobile measurement campaigns are distributed around the world in locations where we most critically need data to incorporate into climate models and improve model performance and predictive capabilities; many of these regions are also of high national and energy security interest. Each of the ARM sites contains scanning radars, lidar systems, and in situ meteorological observing capabilities; the sites are additionally used to demonstrate technologies as they are developed by the community. ARM experiments to study the impact of clouds and aerosols on the Earth's radiative balance address the two most significant scientific uncertainties in climate research. BER is also maintaining the exponentially increasing data archive, with plans for climate projections to have higher resolution, greater sophistication, lower uncertainty, and to better specify tipping points in climate projections (e.g., permafrost thaw and extreme events).

Data sets generated by ARM and from earth system modeling activities are large. The BER data management activity will continue to invest in data-intensive science**.** This research will be in collaboration with the Office of Science's Advanced Scientific Computing Research program.

EMSL provides integrated experimental and computational resources for discovery and technological innovation in the environmental molecular sciences. With more than fifty leading-edge instruments, EMSL enables users to undertake molecular-scale experimental and theoretical research on aerosol chemistry, biological systems, biogeochemistry, and interfacial and surface science. EMSL thus provides a unique opportunity to use multiple experimental systems to provide fundamental understanding of the physical, chemical, and biological processes that underlie DOE's energy and environmental mission areas, including alternative energy sources, improved catalysts and materials for industrial applications, insights into factors influencing climate change and carbon sequestration processes, and subsurface biogeochemical drivers at contaminated sites.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
FY 2011 Current	ARM continued its long-term observations from the fixed sites and provided data from new instruments able to produce 3-D cloud evolution and properties, aerosol composition, meteorological conditions, and surface characterization. A joint field experiment with NASA was conducted to study convective cloud systems in Oklahoma. The mobile facilities supported experiments in India to examine the impact of aerosols on the Indian monsoon and in Colorado to examine liquid and mixed-phase clouds.	101,023

Fiscal Year	Activity	Funding ($000)
	EMSL instruments and supercomputer are operated to support research to obtain a fundamental understanding of the physical, chemical, and biological processes including alternative energy sources such as biofuels; biogeochemical interactions that influence subsurface contaminant movement; improved catalysts and materials for industrial applications; and insights into the molecular reactions that influence climate change and carbon sequestration processes. Funding is continued for the High Magnetic Field Mass Spectrometer. Data management activities continue and carbon cycle data holdings are added to the Earth System Grid, a network for sharing model simulations and observations among the modelers.	
FY 2012 Enacted	ARM will continue its long-term measurements for users to address key scientific uncertainties with a goal to achieve 98% of scheduled operating time. Mobile facilities will support the continuation of the India experiment as well an experiment on the Madden Julian Oscillation on Gan Island in the Indian Ocean. The new mobile facility will initially be located at Oliktok Point, AK for three dimensional measurements of cloud and aerosol properties over land, sea, and ice. The new ARM fixed site in the Azores will provide new long-term observations for marine clouds and aerosols. EMSL will continue to support research to obtain a fundamental understanding of the physical, chemical, and biological processes and a goal to achieve 98% of scheduled operating time. Funding is completed for the High Magnetic Field Mass Spectrometer. Data management activities will continue.	122,074
FY 2013 Request	ARM will continue its long-term measurements at fixed and mobile facilities for users to address key scientific uncertainties. The ARM measurements at Oliktok Point, AK and the Azores will be fully operational. EMSL will continue to support research to obtain a fundamental understanding of the physical, chemical, and biological processes. The focus will be to provide users with enhanced access to new capabilities in molecular beam epitaxy and nano-secondary ion mass spectrometry. Data management activities continue for data-intensive science. The activities advance the use of ARM data to inform and validate the earth system model development.	122,018

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Atmospheric Radiation Measurement Climate Research Facility	45,770	67,977	70,574
Environmental Molecular Sciences Laboratory	51,340	50,324	47,671
Data Management	2,963	2,773	2,773
General Purpose Equipment (GPE)	250	500	500
General Plant Projects (GPP)	700	500	500
Total, Climate and Environmental Facilities and Infrastructure	101,023	122,074	122,018

Supporting Information

Operating Expenses, Capital Equipment and Construction Summary

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Operating Expenses	574,548	577,740	615,035
Capital Equipment	17,873	30,917	9,812
General Plant Projects (GPP)	2,825	900	500
Total, Biological and Environmental Research	595,246	609,557	625,347

Funding Summary

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Research	403,114	375,586	403,261
Scientific User Facilities Operations and Research	181,807	201,696	202,327
Major Items of Equipment	7,250	13,820	0
Facility related GPP	2,125	400	0
Other[a]	950	18,055	19,759
Total, Biological and Environmental Research	595,246	609,557	625,347

Scientific User Facilities Operations and Research

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Biological Systems Science			
Structural Biology Infrastructure	15,765	14,895	14,895
Joint Genome Institute	68,932	68,500	69,187
Total, Biological Systems Science	84,697	83,395	84,082
Climate and Environmental Sciences			
Atmospheric Radiation Measurement Climate Research Facility	45,770	67,977	70,574
Environmental Molecular Sciences Laboratory	51,340	50,324	47,671
Total, Climate and Environmental Science	97,110	118,301	118,245
Total Science User Facilities Operations and Research	181,807	201,696	202,327

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

Facilities Users and Hours

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Joint Genome Institute[a]			
Achieved Operating Hours	8,760	N/A	N/A
Planned Operating Hours	8,400	8,316	8,784
Optimal hours	8,400	8,316	8,784
Percent of Optimal Hours	104.3%	100.0%	100.0%
Unscheduled Downtime Hours	0	N/A	N/A
Number of Users[b]	940	940	940
Atmospheric Radiation Measurement Climate Research Facility (ARM)[c]			
Achieved Operating Hours	8,110	N/A	N/A
Planned Operating Hours	7,884	7,906	7,906
Optimal hours	7,884	7,906	7,906
Percent of Optimal Hours	102.8%	100.0%	100.0%
Unscheduled Downtime Hours	0	N/A	N/A
Number of Users[d]	1,200	1,200	1,300

[a] JGI Planned and Optimal hours are base on being open 24 hours a day, 7 days a week (less holidays, planned downtime for maintenance, installation of new instrumentation, etc.) Actual hours can differ when maintenance and instrument upgrades, etc. take less time than usual.

[b] All JGI users are remote. Primary users are individuals associated with approved projects being conducted at the JGI in a reporting period. Each user is counted once per year regardless of how many proposals their name may be associated with. Additionally, different users reflect vastly differing levels of JGI resources.

[c] ARM Planned and Optimal hours are base on the average over the fixed sites. The hours are estimated based on planned downtime for maintenance, installation of new instrumentation, weather history of each site, etc. Actual hours can differ when maintenance and instrument upgrades, weather related downtime, etc. take less time than usual.

[d] ARM users are both onsite and remote. A user is an individual who accesses ARM databases or uses equipment at an ARM site. Individuals are only counted once per reporting period at an individual site but may be counted at different ARM sites if they are a user at more than one site.

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Environmental Molecular Sciences Laboratory[a]			
Achieved Operating Hours	4,247	N/A	N/A
Planned Operating Hours	4,259	4,296	4,272
Optimal hours	4,259	4,296	4,272
Percent of Optimal Hours	99.7%	100.0%	100.0%
Unscheduled Downtime	12	N/A	N/A
Number of Users[b]	750	750	750
Total Facilities			
Achieved Operating Hours	21,117	NA	NA
Planned Operating Hours	20,543	20,518	20,962
Optimal hours	20,543	20,518	20,962
Percent of Optimal Hours	102.8%	100.0%	100.0%
Unscheduled Downtime Hours	12	N/A	N/A
Number of Users	2,890	2,890	2,990

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

Major Items of Equipment

(Dollars in Thousands)

	Prior Years	FY 2011 Current	FY 2012 Enacted	FY 2013 Request	Outyears	Total	Comple-tion
Atmospheric Radiation Measurement Climate Research Facility (ARM)							
Dual-Frequency Scanning Cloud Radar for Oliktok, Alaska ARM Site (TEC/TPC)	0	0	3,500	0	0	3,500	2Q FY 2013
Dual-Frequency Scanning Cloud Radar for ARM Azores Climate Activity (TEC/TPC)	0	0	3,070	0	0	3,070	2Q FY 2013
Total ARM TEC/TPC		0	6,570	0			

[a] EMSL Planned and Optimal hours are, in general, based on 12 hours a day (6 am–6 pm), seven days a week (4,380 hours), less holidays (96 hours) and less 25 hours in the second quarter for a planned entire building outage. The leap year, as well as planned downtime for maintenance, installation of new instrumentation, etc. can modify the hours available. Actual hours can differ when maintenance, instrument upgrades, etc. take more or less time than planned.
[b] EMSL users are both onsite and remote. Individual users are counted once per year.

(Dollars in Thousands)

	Prior Years	FY 2011 Current	FY 2012 Enacted	FY 2013 Request	Outyears	Total	Comple-tion
Environmental Molecular Sciences Laboratory (EMSL)							
Next Generation, High Magnetic Field Mass Spectrometer (TEC/TPC)	3,000	7,250	7,250	0	0	17,500	1Q FY 2016
Total BER TEC/TPC		7,250	13,820	0			

Atmospheric Radiation Measurement Climate Research Facility

Dual-frequency scanning cloud radar for the ARM Arctic Climate activity. This instrument will provide the capability to measure cloud properties in a volume and will provide three-dimensional cloud properties at Oliktok, Alaska: essential data for developing high-resolution climate models.

Dual-frequency scanning cloud radar for the ARM Azores Climate activity. This instrument will provide the capability to measure cloud properties in a volume and will provide three-dimensional cloud properties in the Azores: essential data for developing high-resolution climate models.

Environmental Molecular Sciences Laboratory

Next Generation, High Magnetic Field Mass Spectrometer system is a world-leading system to measure and characterize complex mixtures of intact proteins and other biomolecules, aerosol particles, petroleum, and constituents from other types of fluids. The Total Project Cost (TPC) was reviewed and approved at CD-2/3a, Approve Performance Baseline and Authorization to Award Magnet Procurement Contract, on August 30, 2011. The system will enable world-leading proteomics, metabolomics, and lipidomics with application to bioenergy, as well as provide insights relevant to climate science, fossil fuel processing, and catalysis.

Scientific Employment

	FY 2011 Actual	FY 2012 Estimate	FY 2013 Estimate
# University Grants	467	470	480
Average Size per year	$336,000	$340,000	$340,000
# Laboratory Projects	197	195	200
# Permanent Ph.D.s[a]	1,500	1,500	1,515
# Postdoctoral Associates[b]	345	345	350
# Graduate Students[b]	495	495	500
# Ph.D.s awarded[c]	110	110	110

[a] The number of permanent Ph.D.s is estimated. Information is not readily available on the total number of permanent Ph.D. scientists associated with each research project. In addition to the principal investigator for each research project funded by BER, individual projects typically have between 1 and 20 additional Ph.D.-level scientists who are funded collaborators. Information on scientific collaborators is not routinely tracked.

[b] The number of Postdoctoral Associates and graduate students is estimated for national laboratory projects.

[c] The number of Ph.D.s awarded is estimated. Information is not available on the number of Ph.D.s awarded as a result of BER funded research at universities or national laboratories.

Fusion Energy Sciences
Funding Profile by Subprogram and Activity

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Science			
DIII-D Research	30,716	30,300	26,703
Alcator C-Mod Research	10,056	10,454	8,396
International Research	6,105	7,435	8,946
Diagnostics	4,115	3,519	3,519
Other	8,085	11,919	9,193
NSTX Research	16,107	17,549	16,836
Experimental Plasma Research	17,745	11,000	10,500
High Energy Density Laboratory Plasmas	25,727	24,741	16,933
Madison Symmetric Torus	7,005	6,000	5,750
Theory	25,663	24,348	20,836
SciDAC	7,057	8,312	6,556
General Plasma Science	14,810	16,780	13,151
SBIR/STTR	0	8,167	6,881
Total, Science	173,191	180,524	154,200
Facility Operations			
DIII-D	35,699	38,319	33,260
Alcator C-Mod	17,518	18,067	7,848
NSTX	32,559	32,134	29,393
Other, GPE, and GPP	4,568	975	975
MIE: U.S. Contributions to ITER Project	80,000	105,000	150,000
Total, Facility Operations	170,344	194,495	221,476
Enabling R&D			
Plasma Technology	14,501	13,911	11,666
Advanced Design	2,752	4,337	1,611
Materials Research	6,469	7,729	9,371
Total, Enabling R&D	23,722	25,977	22,648
Total, Fusion Energy Sciences	367,257[a]	400,996[b]	398,324

[a] Total is reduced by $8,205,000, $7,326,000 of which was transferred to the Small Business Innovation Research (SBIR) program and $879,000 of which was transferred to the Small Business Technology Transfer (STTR) program.
[b] The FY 2012 appropriation is reduced by $1,181,000 for the Fusion Energy Sciences share of the DOE-wide $73,300,000 rescission for contractor pay freeze savings. The FY 2013 budget request reflects the FY 2013 impact of the contractor pay freeze.

Public Law Authorizations

Public Law 95-91, "Department of Energy Organization Act," 1977
Public Law 109-58, "Energy Policy Act of 2005"
Public Law 110-69, "America COMPETES Act of 2007"
Public Law 111-358, "America COMPETES Act of 2010"

Program Overview and Benefits

The Fusion Energy Sciences (FES) mission is to expand the fundamental understanding of matter at very high temperatures and densities and to build the scientific foundation needed to develop a fusion energy source. This is accomplished by studying plasma and its interactions with its surroundings across wide ranges of temperature and density, developing advanced diagnostics to make detailed measurements of its properties and dynamics, and creating theoretical and computational models to resolve the essential physics principles.

A leading societal benefit of FES research is establishing the scientific basis for fusion energy. Controlled fusion has the potential of delivering base-load power for developed and emerging economies with a fuel supply that is abundant and available to all nations. The fundamental process of producing energy from fusion yields zero greenhouse gas emissions. There is no possibility of a runaway reaction or meltdown with fusion, and any radioactive waste will be low-level. The science of fusion frames many aspects of astrophysical sciences and enables quantitative understanding of a broad class of exotic phenomena that are observed in the universe and can be established in the laboratory. Beyond this, plasma science supported by FES is central to myriad applications ranging from optimization of processes in the semiconductor industry to development of technologies deployed for national defense and homeland security.

The pursuit of fusion energy embraces the challenge of bringing the energy-producing power of a star to earth. The promise of fusion as an energy source with plentiful fuel supplies from the sea, modest resulting radioactivity, and potentially minimal environmental footprint is substantial. And, the science is rich and full of possibility for discovery. The pursuit is one of the most challenging programs of scientific research and development that has ever been undertaken, and its science reaches far beyond the realm of fusion itself. With the support of FES, a devoted, expert, and innovative scientific and engineering workforce has been responsible for the impressive progress toward establishing the scientific basis for fusion on earth since the earliest experiments over sixty years ago. As a result, we are now positioned to conduct scientific experiments that will test the future feasibility of fusion energy.

The science underpinning much of fusion energy research is plasma physics. Plasmas—the fourth state of matter—are like hot gases, except that they are so hot that electrons have been knocked free of atomic nuclei, forming an ensemble of ions and electrons that can conduct electrical currents and can respond to electric and magnetic fields. The science of plasmas is elegant, far-reaching, and impactful. Composing over 99% of the visible universe, plasmas are also pervasive. It is the state of matter of the sun's center, corona, and solar flares. Plasma dynamics is at the heart of the extraordinary formation of galactic jets and accretion of stellar material around black holes. On earth it is the stuff of lightning and flames. Plasma physics describes the processes giving rise to the aurorae that gently illuminate the far northern and southern nighttime skies. Practical applications of plasmas are found in lighting, semiconductor manufacturing, and televisions.

On earth, fusion is routinely created and controlled in our research laboratories; experiments have generated millions of watts of fusion power for seconds at a time. In a working reactor, some of the energy would be captured by the plasma itself, enabling more fusion reactions to be sustained, while the energy of the energetic ions and neutrons that escape the plasma would be captured and converted into heat. This heat would drive conventional power plant equipment to boil water, generate steam, and turn turbines to put power on the grid. The leading approach to fusion being studied in the world is confining a hot plasma with a magnetic field. This approach is the primary focus of the research conducted in the FES program. A second approach is to compress the fuel, thereby raising its temperature rapidly, and then to rely on the inertia of the fuel itself to keep it confined long enough for fusion to happen. The plasma science of this inertial fusion energy approach is part of a broader class of science that includes and extends beyond inertial fusion: high energy density laboratory plasma physics. High Energy Density Laboratory Plasma (HEDLP) physics is stewarded in part through a program managed and sponsored jointly by the National Nuclear Security

Administration (NNSA) and FES. In the last two decades, progress in our understanding of plasma systems and their control requirements has enabled researchers to move toward generating self-sustaining, or burning, plasmas. For both magnetic and inertial fusion, new experimental plans are being developed to make first studies of fusion plasma systems where the energy produced in the fusion process is substantially greater than the energy applied externally to heat and control the plasma. The flagship program for achieving this is the ITER project, an international fusion research project being constructed in Cadarache, France. ITER's primary scientific goal is to create and enable the study of sustained, high-gain burning plasmas for the first time.

Another great scientific challenge for fusion is understanding and developing materials that can tolerate the extreme conditions in a fusion environment. A plasma at a high enough temperature and density to enable sustained nuclear fusion presents a uniquely hostile environment to the materials comprising the system, due to enormous heat fluxes—tens of millions of watts per square meter impinging on a wall—and to a harsh shower of neutrons that will displace constituent atoms and thus qualitatively change the materials' strength and other characteristics. An opportunity for the U.S. to assert international leadership over the next decade resides in the broad area of material science application to Fusion Energy Science.

Fusion and plasma science research is grounded in a deep, experimentally validated theoretical understanding that is growing in parallel with experimental accomplishments. Modeling and simulation are being used as tools for discovery that are guiding experimental choices, a sign of increasing maturity of the scientific field. Nurturing this class of research in national labs and universities, including creating targeted experimental platforms for validating the theories represented in the computer modeling and simulation codes, is a high priority for U.S. fusion science. FES also supports research outside the realm of fusion. Plasma physicists are helping to unravel mysteries ranging from the anomalous heating of the solar corona to the origin of magnetic fields in the universe. Fusion's theory-based computational tools have been used recently to explain the unexpectedly low brightness of the accretion plasma disk surrounding super massive black holes in the center of our galaxy.

Basic and Applied R&D Coordination

FES and NNSA have a joint program in HEDLP physics to provide stewardship in this area. The FES high energy density physics program includes discovery-driven fundamental research that is central to understanding a broad range of natural systems, including the cores of the giant planets as well as the interiors of stars. A discovery-driven plasma physics program is also carried out in concert with the National Science Foundation (NSF). Research extends to a wide range of natural phenomena, including the origin of magnetic fields in the universe and the physics of enormous plasma heating of the solar corona. Both joint programs include partnership in coordinating solicitations, peer reviews, and scientific workshops. The Fusion Energy Sciences Advisory Committee (FESAC) provides technical and programmatic advice to FES and NNSA for the joint HEDLP program.

Program Accomplishment and Milestones

ITER continues forward. The ITER Project has moved into the construction phase under the leadership of a new Director General (DG). The DG has assembled a leadership team of project management and administration professionals from around the world, including the U.S., to aggressively manage construction and to minimize construction costs and delays. Activities in FY 2011 included launching of a task group that includes U.S. ITER Project Office (USIPO) and FES leadership to develop a revised Integrated Project Schedule. This activity has helped minimize delays resulting from the Japanese earthquake.

U.S-led research in instability control has international impact. A type of plasma instability in tokamaks called an edge localized mode (ELM) can lead to ejections of energy, which could potentially damage the plasma facing components of a magnetic fusion power plant. First-of-a-kind research on DIII-D to develop ways to avoid ELMs reached a new level of maturity in 2011. Research results from DIII-D are being explored and reproduced on the Axially Symmetric Divertor Experiment-Upgrade (ASDEX-U) device in Garching, Germany, and the international ITER project is undertaking a design effort to include the capability identified in the DIII-D research. The research has also spawned national and international computational efforts to understand the physics underlying these results with the goal of establishing the basis for implementing these approaches on future fusion devices.

U.S. scientists are enabling maturation of the research capabilities of emergent, state-of-the-art research facilities overseas. U.S. scientists led in the implementation of plasma control and wall preparation systems on Korea's Superconducting Tokamak Advanced Research (KSTAR) and China's Experimental Advanced Superconducting Tokamak (EAST) experiments. Enabled by these tools, both facilities achieved stationary high-confinement plasmas with significantly increased energy stored in the plasmas in FY 2011. The techniques applied were developed through plasma control science in the U.S. over the last decade and have enabled the facilities to rapidly enter plasma confinement regimes that are relevant to fusion research.

Antihydrogen atoms trapped in the laboratory for more than 15 minutes. The trapping and measurement of antimatter tests our most basic understanding of the forces of nature. Antihydrogen, made entirely of antiparticles, is believed to be stable, and this longevity holds the promise of precision studies of matter-antimatter symmetry. FES supports several members of an international collaboration, including faculty of the University of California, Berkeley, who have overcome the challenges of confining plasmas of neutral and charged particles in overlapping regions, as well as maintaining sufficiently low energy to trap the atoms. Recent results showing the containment of 300 antihydrogen atoms for up to 1,000 seconds strongly imply that the antihydrogen atoms have reached their lowest-energy (ground) state while in the trap, which allows for ground-state spectroscopy. In addition, the large number of atoms allows researchers to compare the time and position at which the atoms escape the trap to simulations and shed light on the energy distribution of the trapped atoms.

Milestones	Date
The National Spherical Torus Experiment (NSTX) Upgrade Major Item of Equipment (MIE) project is scheduled to achieve Critical Decision-3 (CD-3) in the second quarter of FY 2012. (Note: The project actually achieved CD-3 in December 2011, one month ahead of the target date.)	2nd Qtr, FY 2012
The Neutralized Drift Compression Experiment-II (NDCX-II) at Lawrence Berkeley National Laboratory, a Recovery Act-funded project, will complete all construction activities in FY 2012.	2nd Qtr, FY 2012
The U.S. ITER Project Office (USIPO) plans to successfully execute U.S.-controlled prerequisite activities to achieve CD-2 in FY 2012. CD-2 will establish an overall cost and schedule for the USIPO to complete delivery of U.S. contributions to the ITER construction phase. Meeting the CD-2 milestone requires establishing the overall ITER cost and schedule and completing a number of management and cost reviews in the U.S.	4th Qtr, FY 2012
FES and the Advanced Scientific Computing Research (ASCR) program will assess the findings of the Fusion Simulation Program (FSP) Planning Study and determine an appropriate path forward.	4th Qtr, FY 2012

Explanation of Changes

The most notable changes in this budget proposal as compared to previous years are as follows:

- *Increase in the request for U.S. ITER Project funding*—The goals of ITER represent the capstone of over fifty years of research in magnetically confined fusion. The U.S. remains committed to the scientific mission of ITER, while maintaining a balanced research portfolio, and will work with ITER partners to accomplish this goal. U.S. engagement in the ITER project will require both near- and long-term investment. The funding increase for the U.S. contributions to the ITER Project will enable the U.S. to make long-lead procurements as the project enters its construction period.
- *Overall reduction in domestic research*—Due to the need to retain overall program balance, the request for domestic research in most areas is reduced.
- *Cessation of operations of the Massachusetts Institute of Technology*'s *(MIT) Alcator C-Mod tokamak*—Some of the savings from the termination of Alcator C-Mod research operations at MIT offset

increases for ITER and allow capturing new higher-priority scientific opportunities. These include long-pulse plasma research to be conducted on emergent superconducting-magnet-based research facilities overseas and research in materials science.

Program Planning and Management

A hierarchy of sources guides the development of the FES program vision as well as particular programmatic choices. Influencing overall FES program vision are studies by the National Research Council (NRC) of the National Academy of Sciences. Federal advisory committee-based studies are undertaken to identify strategic elements and to further inform particular approaches. The advisory committee studies are supported by community-based activities to identify broad classes of research needs in particular areas.

As leading examples of studies that have shaped FES's approach to program planning at the highest level, the 2004 NRC study, *Burning Plasmas: Bringing a Star to Earth*[a], underscored the readiness and opportunities for the U.S. to participate in a magnetically confined burning plasma experiment such as ITER. *Plasma Science: Advancing Knowledge in the National Interest* (2007)[b] urged SC to exercise strong federal stewardship of general plasma science including and beyond fusion energy applications. Seeking input from the Academies is an ongoing process. The National Academies is currently assessing inertial fusion energy (IFE) science and technology prospects and needs. The output may suggest opportunities for FES engagement in the science of IFE, most notably high energy density laboratory plasma physics.

Fusion Energy Science Advisory Committee (FESAC) subpanel activities that have been particularly influential include a comprehensive analysis of gaps in the world program titled *Priorities, Gaps, and Opportunities: Towards a Long Range Strategic Plan for Magnetic Fusion Energy* (2007). The report highlighted needs for fusion science overall and opportunities for U.S. leadership. This report was followed by a community-wide effort that yielded a Magnetic Fusion Energy Sciences (MFES) Research Needs Workshop (ReNeW) and a report, *Research Needs for Magnetic Fusion Energy Sciences* (2009). The ReNeW report describes a broad palette of scientific research that could be executed in parallel with ITER that would develop the scientific and technical basis for fusion energy. Recently, FESAC was charged with building on the *Priorities, Gaps, and Opportunities* study and the ReNeW activity to clarify in greater detail the research opportunities in fusion materials science and those presented by partnership with internationally based research endeavors, where some of these scientific and technical opportunities reside.

Beyond magnetic fusion, FES sponsored a series of workshops during 2008 and 2009 focused on providing additional input so as to identify opportunities for general plasma science. The first workshop covered the field of low temperature plasma physics and produced the report entitled *Low Temperature Plasma Science: Not only the Fourth State of Matter but All of Them* (2008). A workshop of a similar nature to ReNeW was held regarding HEDLP (2009), yielding a report entitled *Basic Research Needs for High Energy Density Laboratory Physics,* published in October 2010. A FESAC report on scientific issues and opportunities in both fundamental and mission-driven HEDLP, *Advancing the Science of High Energy Density Laboratory Plasmas* (2009), was used as the technical basis for the workshop. SC and NNSA have jointly appointed FESAC as the Federal Advisory Committee for the FES-NNSA joint program in HEDLP.

Every three years, a FESAC Committee of Visitors (COV) panel assesses the efficacy and quality of the FES processes used to solicit, review, recommend, monitor, and document the application, proposal, and award actions and the quality of the resulting portfolio. The most recent COV report, from 2010, is *Fusion Energy Sciences Advisory Committee: Report on a Committee of Visitors-Review of Procedures and Processes Used to Solicit and Fund Research at Universities, National Laboratories and Industrial Firms*.

Program Goals and Funding

FES has four strategic goals:

- Advance the fundamental science of magnetically confined plasmas to develop the predictive capability needed for a sustainable fusion energy source;

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[a] Available at http://www.nap.edu/catalog.php?record_id=10816.
[b] Available at http://www.nap.edu/catalog.php?record_id=11960.

- Support the development of the scientific understanding required to design and deploy the materials needed to support a burning plasma environment;
- Pursue scientific opportunities and grand challenges in high energy density plasma science to explore the feasibility of the inertial confinement approach as a fusion energy source, to better understand our universe, and to enhance national security and economic competitiveness, and;
- Increase the fundamental understanding of basic plasma science, including both burning plasma and low temperature plasma science and engineering, to enhance economic competiveness and to create opportunities for a broader range of science-based applications.

Office of Science performance expectations (and therefore funding requests) are focused on four areas:

- Research: Support fundamental research to increase our understanding of and enable predictive control of the plasma state and its surrounding environment.
- Facility Operations: Maximize the reliability, dependability, and availability of the FES scientific user facilities to enable U.S. researchers to define world leading research in the fusion energy and plasma sciences.
- Future Facilities: Build future and upgrade existing facilities and experimental capabilities to get the best value from investments and advance continued U.S. leadership in the fusion energy and plasma sciences.
- 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	Facility Operations	Future Facilities	Workforce
Science	100%	0%	0%	0%
Facility Operations	0%	20%	80%	0%
Enabling R&D	100%	0%	0%	0%
Total, Fusion Energy Science	45%	10%	45%	0%

Explanation of Funding and Program Changes

	(Dollars in Thousands)		
	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Science	180,524	154,200	-26,324

The overall decrease in the Science subprogram is driven by the FY 2013 constrained budgetary environment. Domestic research in most areas is reduced, while program balance is retained. A small new initiative in International Collaborations is started.

	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Facility Operations	194,495	221,476	+26,981

The growth is driven by increases to the U.S. contributions to ITER Project as the pace of construction increases and significant procurement contracts are placed with domestic suppliers for component fabrication.

(Dollars in Thousands)	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Enabling R&D	25,977	22,648	-3,329
The decrease is driven by the FY 2013 constrained budgetary environment. Research in most areas is reduced, although a small new initiative in fusion materials research is proposed.			
Total Funding Change, Fusion Energy Sciences	400,996	398,324	-2,672

Science
Funding Profile by Activity

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
DIII-D Research	30,716	30,300	26,703
Alcator C-Mod Research	10,056	10,454	8,396
International Research	6,105	7,435	8,946
Diagnostics	4,115	3,519	3,519
Other	8,085	11,919	9,193
NSTX Research	16,107	17,549	16,836
Experimental Plasma Research	17,745	11,000	10,500
High Energy Density Laboratory Plasmas	25,727	24,741	16,933
Madison Symmetric Torus	7,005	6,000	5,750
Theory	25,663	24,348	20,836
SciDAC	7,057	8,312	6,556
General Plasma Science	14,810	16,780	13,151
SBIR/STTR	0	8,167	6,881
Total, Science	173,191	180,524	154,200

Overview

The Science subprogram is developing a predictive understanding of plasma properties, dynamics, and interactions with surrounding materials. The greatest emphasis is on understanding magnetically confined fusion-grade plasmas, but the subprogram also encompasses high energy density laboratory plasma science, plasma-material interactions, and general plasma science. Among the activities supported by this subprogram are:

- Research at the major experimental facilities aimed at resolving fundamental issues of fusion plasma physics and developing predictive science needed for ITER operations and providing solutions to high-priority ITER issues.
- Research on small- and medium-scale experiments to elucidate the underlying physics principles upon which concepts of toroidal confinement are based and to validate theoretical models and simulation codes.
- Research performed at a new generation of foreign fusion research facilities to exploit their unique capabilities and characteristics.
- Theoretical work on the fundamental science of magnetically confined plasmas and development of advanced simulation codes capable of exploiting current and emerging high performance computing resources.
- Development of unique measurement capabilities and diagnostic instruments to enable experimental validation and provide sensory tools for feedback control of fusion devices.
- Research addressing fundamental scientific questions on high-energy-density laboratory plasmas, through experimental, theoretical, and modeling efforts, and particularly leveraging unique capabilities of federal investments in inertial confinement devices.

Explanation of Funding Changes

Significant reductions in the Science subprogram are necessary to retain program balance. There are reductions in nearly all areas except for diagnostics development and international collaboration. Funding for the development of advanced diagnostics is maintained at the FY 2012 level, and a modest increase in funding for scientific collaborations on major international facilities will permit U.S. scientists to carry out research on a new generation of superconducting confinement facilities. Alcator C-Mod will be permanently shut down in FY 2013, and NSTX will not operate during its major upgrade. Most of the Alcator C-Mod research staff will be maintained and will begin to transfer to collaborations on other domestic or international facilities.

(Dollars in Thousands)

	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
DIII-D Research	30,300	26,703	-3,597
The reduction reflects a priority for operations (run time) in FY 2013, with the transition of some research staff to international collaboration efforts and increased involvement in experiments at overseas facilities.			
Alcator C-Mod Research	10,454	8,396	-2,058
Alcator C-Mod is shut down in FY 2013, but most of the research staff will be maintained in FY 2013 in order to complete analysis of data taken in FY 2012 and publish the results. A transition of research staff into collaborative activities on other domestic and international experiments will begin.			
International Research	7,435	8,946	+1,511
This growth in funding will expand scientific collaboration on a new generation of foreign fusion research facilities, especially the EAST (China) and KSTAR (Korea) superconducting tokamaks and the Wendelstein 7-X (Germany) stellarator.			
Other	11,919	9,193	-2,726
Support for the U.S. Burning Plasma Organization and the FES educational and outreach programs will be reduced.			
NSTX Research	17,549	16,836	-713
The NSTX research staff (both PPPL personnel and outside collaborators) will be temporarily reduced during the shutdown for the upgrade of NSTX. The remaining researchers will be involved in collaborations on other domestic and foreign facilities, development of the NSTX-Upgrade research plan, and fabrication of new or upgraded diagnostics for the first experimental campaign on NSTX-Upgrade.			
Experimental Plasma Research (EPR)	11,000	10,500	-500
Support for this research is kept nearly flat. Consisting of small-scale experiments primarily at universities, this portfolio's emphasis is on plasma physics and some classes of materials science studied in a wide range of magnetic configurations. Research studies focus on understanding the connections to tokamak-relevant physical phenomena, thereby broadening the physics basis for both tokamaks and non-tokamaks.			

	(Dollars in Thousands)		
	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
High Energy Density Laboratory Plasmas (HEDLP)	24,741	16,933	-7,808
The HEDLP research portfolio is reduced. The HEDLP program will continue to address the needs and opportunities identified in the FESAC report on scientific issues and opportunities in both fundamental and mission-driven HEDLP, albeit at reduced scope. Program specifics will be informed by the outcome of a competitive merit review of much of the program in FY 2012 and FY 2013, the forthcoming National Research Council (NRC) Inertial Fusion Energy (IFE) study report, and programmatic priorities.			
Madison Symmetric Torus (MST)	6,000	5,750	-250
Support for this experiment is kept nearly flat.			
Theory	24,348	20,836	-3,512
The constrained budget will result in funding decreases and possible project cancellations at universities and national laboratories and will narrow the scope of the program.			
SciDAC	8,312	6,556	-1,756
Funding levels for projects in the portfolio will be reduced. The scope and balance of the portfolio will be maintained, but fewer Centers may be selected for an award following the FY 2012 recompetition of a significant portion of the FES SciDAC program.			
General Plasma Science	16,780	13,151	-3,629
Activities in General Plasma Science (GPS) research will be reduced overall. Commitments to NSF/DOE interagency activities will be maintained. Program balance of the GPS projects will be critically reviewed through competitive peer review.			
SBIR/STTR	8,167	6,881	-1,286
In FY 2011, \$7,326,000 and \$879,000 were transferred to the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs, respectively. SBIR/STTR funding is set at 2.95% of non-capital funding in FY 2012 and 3.05% in FY 2013.			
Total Funding Change, Science	180,524	154,200	-26,324

DIII-D Research

Overview

The DIII-D Research goal is to establish the scientific basis for the optimization of the tokamak approach to fusion energy. DIII-D is a world leader in establishing the scientific basis for magnetic fusion on earth and understanding the ultimate potential of the tokamak concept as a fusion device. Much of this research concentrates on the development of the advanced tokamak concept, in which active control techniques are used to manipulate and optimize the plasma in aspects such as MHD stability margin, thermal transport and heating profiles, pumping of fusion fuel, and local current density, so as to obtain plasmas that scale to robust operating points and high fusion gain for a future reactor and ITER research scenarios. Building on this, targeted efforts address scientific issues that are important to ITER's design, including the science of the influence of ELM coils to be used to stabilize edge MHD. Longer-term research has had a significant impact on operating scenarios envisioned for the ITER device and has the promise of continuing to do so. Another area of high importance is general fusion science, pursuing a basic scientific understanding across all fusion plasma topical areas including transport, stability, plasma-wave physics, and boundary layer physics.

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

The DIII-D program is operated as a national research effort, with extensive participation from many U.S. laboratories and universities who receive direct funding from FES. The DIII-D program also plays a central role in U.S. international collaborations with the European Union, Japan, Korea, China, India, and Russia, hosting many foreign scientists. DIII-D scientists also participate in foreign experiments. DIII-D research scientists lead and participate in topical studies organized by the U.S. Burning Plasma Organization (USBPO) and the International Tokamak Physics Activity (ITPA).

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	In FY 2011 DIII-D researchers began utilizing new tools added during the most recent facility upgrade. New capability to inject heating power off the central axis of the tokamak was used to study the effects of off-axis heating and current drive. Exploration of operating modes without harmful edge localized modes was performed with the use of the internal and external magnetic perturbation coils. An upgraded diagnostic system provided high-resolution edge temperature and density measurements to improve the fundamental understanding of energy transport in high performance plasmas.	30,716
2012 Enacted	After a brief operating period at the beginning of FY 2012, during which experiments were conducted to simulate the potential effects of the ITER test blanket modules, additional facility upgrades are being completed. Research in the second half of FY 2012 uses additional microwave heating capability, added through an ARRA project, to study plasmas more relevant to burning plasma conditions. Advanced imaging techniques enable more detailed studies of the plasma edge region.	30,300
2013 Request	Research in FY 2013 will focus on using the existing microwave heating, neutral beam, and diagnostic systems to explore advanced tokamak plasmas and address scientific issues important to ITER and advanced fusion plasma system concepts. The DIII-D program will continue to strengthen collaborations with the international community by hosting and participating in joint experiments.	26,703

Alcator C-Mod Research

Overview

The Alcator C-Mod Research activity uses a compact, high-performance, divertor tokamak to establish the plasma physics and plasma engineering necessary for a burning plasma tokamak experiment and for attractive fusion reactors. C-Mod research is organized around integrated operating scenarios at plasma conditions relevant to fusion energy production. The study of these integrated scenarios is supported by research in topical science areas, with the goal to develop a predictive understanding of the physical processes underlying the performance of tokamak fusion plasmas.

The C-Mod tokamak is a compact device that uses intense magnetic fields to confine high-temperature, high-density plasmas in a small volume. The C-Mod research team has made significant contributions to the world's fusion program in many areas relevant to burning plasmas.

The C-Mod program is operated as a national research effort, with participation from U.S. laboratories and other universities. Housed at a university, the program has served to educate a large number of fusion research scientists. C-Mod scientists have also led and participated in topical studies organized by the USBPO and the ITPA. The C-Mod facility will be closed in FY 2013, as described in the Facility Operations section.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	Research in FY 2011 used a new antenna system to study the coupling of Lower Hybrid (LH) waves to the plasma for heating and current drive. Extensive comparisons to theory and modeling were conducted to expand understanding of LH heating and current drive effects. An improved operating mode that exhibited an edge temperature pedestal without the usual coexistent particle density pedestal was further examined and the operating space expanded.	10,056
2012 Enacted	In FY 2012, the C-Mod team uses a new radiofrequency (RF) antenna that was supported with ARRA funding. This advanced antenna has been designed to match the geometry of C-Mod in order to examine plasma antenna interaction effects. The C-Mod team also concentrates on several other ITER- and power plant-relevant topics, such as disruption mitigation techniques and a targeted effort to improve understanding of core transport physics and enhance the capability to predict core temperature and density profiles. High priority is given to performing experiments required to complete the educational requirements of the C-Mod graduate students.	10,454
2013 Request	While no operations are planned in FY 2013 as the C-Mod facility is shut down, most of the research staff will be retained in FY 2013 to evaluate data taken in prior years and publish the results, while beginning the transition to collaborative activities involving experiments on other domestic and international facilities.	8,396

International Research

Overview

In addition to their work on domestic facilities, U.S. researchers have participated in experiments at fusion facilities in Europe, Japan, Russia, China, South Korea, and India for a number of years. In return, the U.S. hosts foreign researchers at our domestic facilities.

U.S. researchers will have opportunities to participate in experiments on a new generation of magnetic confinement experiments that have been or are being built overseas. Superconducting tokamaks based on U.S. designs are now operating in China (EAST) and South Korea (KSTAR), and a new superconducting stellarator (Wendelstein 7-X) will begin operation in Germany in 2014. The FES program can both contribute to and benefit from scientific collaborations on these facilities.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	U.S. scientists collaborated on several major foreign facilities, including the Joint European Torus (JET) in England, the world's highest performance tokamak; the Large Helical Device in Japan, a superconducting stellarator; Tore Supra in France, a large superconducting tokamak; ASDEX-U in Germany, a tokamak testing tungsten as a first wall material; EAST in China; and KSTAR in South Korea.	6,105
2012 Enacted	In FY 2012, U.S. researchers continue to be involved at these foreign facilities. Experiments on JET concentrates on optimizing plasma performance in a facility lined with ITER-like plasma facing components. In ASDEX-U, the focus is on operation with tungsten walls and control of edge instabilities with internal magnet coils. In addition, U.S. researchers apply their expertise in stellarator physics to begin fabricating a set of trim coils for Wendelstein 7-X for use in joint experiments on stellarator optimization.	7,435
2013 Request	In FY 2013, FES will expand collaborations on unique foreign facilities, such as superconducting tokamaks and stellarators. These facilities will ultimately be able to explore sustainment and control of magnetically confined plasmas for hundreds of seconds. Such scientific collaborations will help to maintain a vigorous U.S. fusion community that is active at the frontiers of fusion research. U.S. researchers will complete the fabrication of the set of trim coils for Wendelstein 7-X, and these coils will be delivered to Germany as required to meet the Wendelstein 7-X construction schedule.	8,946

Diagnostics

Overview

Diagnostics are the scientific instruments used to make detailed measurements of the physical phenomena inside a 100 million degree plasma. New observations leading to scientific breakthroughs are often enabled by the development of a new diagnostic technique or methodology. In order to advance fusion energy sciences, improvements to plasma control and stronger connections of experiments to theory and simulation are required. Advances in the science of diagnostics are therefore required to provide a link between theory/computation and experiments and to provide sensory tools for feedback control of plasma properties. This program activity involves developing new diagnostic techniques and the theory supporting the application of existing diagnostic methods.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	Funds supported grants to conduct research on the development of advanced diagnostics including an x-ray imaging crystal spectrometer, a motional Stark effect diagnostic, a heavy ion beam probe, and techniques for measuring electron current density, turbulence, zonal flows, particle flux, edge plasmas, and plasma fluctuations.	4,115
2012 Enacted	In FY 2012, the research described above is continued at a reduced level. Community input is solicited for laying out a roadmap for diagnostics research in the next five- to ten-year time frame.	3,519
2013 Request	A solicitation for new research in this program activity for both national laboratories and non-laboratory institutions (universities and private industry) will be issued.	3,519

Other

Overview

Funding in this category supports educational activities such as research at Historically Black Colleges and Universities (HBCUs), the SC Early Career Research Program, postgraduate fellowships in fusion science and technology, and summer internships for undergraduates.

In addition, funding in this category supports outreach efforts related to fusion science and enabling research and development, and the activities of the U.S. Burning Plasma Organization, a national organization that coordinates research in burning plasma science, and the Fusion Energy Sciences Advisory Committee.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	Support for HBCUs included research areas in divertor tokamaks, plasma turbulence, materials research, and tokamak plasmas. FES supported the SC Early Career Research Program in five topical areas: experimental plasma science, theory and modeling, high energy density plasma science, general plasma science, and materials science and technology. Education and outreach activities supported the engagement of K-14 educators and students in STEM fields related to fusion energy. Additionally FES continued to support educational opportunities in fusion science for post-graduate students.	8,085
2012 Enacted	FES plans to continue its support for HBCUs in the fusion and plasma sciences, the SC Early Career Research Program, education and outreach activities supporting the engagement of K-14 educators and students in STEM fields related to fusion energy, and education opportunities for post-graduate students.	11,919
2013 Request	FES will continue support for all the elements in this category at a reduced level.	9,193

NSTX Research

Overview

The National Spherical Torus Experiment (NSTX) is a national scientific user facility designed to explore the physics of plasmas confined in a spherical torus (ST) configuration, which is characterized by a lower aspect ratio between the height and width of the device. The research focus of NSTX is to establish the potential of the ST configuration as a means for achieving fusion plasmas with very high ratios of plasma pressure to magnetic field pressure and to make unique contributions to the scientific understanding of magnetic confinement in the areas of electron energy transport, liquid metal plasma-material interfaces, and energetic particle confinement for burning plasmas. NSTX will be upgraded to higher magnetic field, higher plasma current, and stronger neutral beam heating and, after achievement of CD-4, renamed as NSTX-Upgrade (NSTX-U). If successful, NSTX-U could establish the scientific basis for a compact fusion research facility that would be central to exploring the scientific and technological issues associated with harnessing the power generated by magnetically confined fusion and breeding tritium continuously in a reactor. Research on NSTX-U is conducted by a collaborative research team of physicists and engineers from about 30 U.S. laboratories and universities.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	During four weeks of research operation at the beginning of FY 2011, the NSTX researchers carried out experiments on plasma stability and control, plasma startup, and plasma-wall boundary physics. During a seven-month shutdown, the NSTX team installed a few minor facility upgrades and several diagnostic upgrades, many of which were fabricated with ARRA funding. In July 2011, while integrated systems tests were being carried out in preparation for 10 additional weeks of research operations, there was an arc that damaged the main magnetic field coils. A detailed assessment determined that the cause of the failure was a degradation of the insulation between conductors and that the coils would have to be completely rebuilt, which would take up to 12 months. The NSTX team recommended proceeding immediately with the upgrade, and FES approved doing so.	16,107
2012 Enacted	The NSTX team began fabrication of the new center stack and preparation to install the second neutral beam line in December 2011. The NSTX team analyzes existing data, carries out analyses to support the upgrade project and plan for future research operations, and prepares for collaborations on domestic and foreign facilities.	17,549
2013 Request	In FY 2013, the NSTX-U facility will still be shut down due to the upgrade NSTX researchers will continue to analyze existing data and begin collaborations on domestic and foreign facilities that can carry out experiments relevant to the future NSTX-U program. These experiments include plasma start-up, lithium first-wall coatings, energy and particle confinement, plasma stability and control, energetic particle physics, and radio frequency heating.	16,836

Experimental Plasma Research (EPR)

Overview

Experimental Plasma Research (EPR) provides experimental data in regimes of relevance to the FES mainline magnetic confinement and materials science efforts and helps validate theoretical models and simulation codes in support of the FES goal to develop an experimentally-validated predictive capability for magnetically-confined fusion plasmas. EPR's goal is to generate sufficient experimental data to elucidate the underlying physics principles upon which concepts of toroidal confinement are based and, as needed, to develop computational models to a sufficient degree of scientific fidelity to allow an assessment of the relevance of those concepts to future fusion energy systems. EPR experiments provide unique tests and extensions to enhance the understanding of magnetically-confined plasmas. Recent investments have supported the operation of a range of experimental facilities, a center that provides theory and computational support to EPR experiments, and several small topic-specific investigations.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	Following a competitive external peer review of all projects in FY 2010, the first year of research for the reconstituted EPR portfolio was begun. Termination costs were allocated to five projects in their final year of research.	17,745
2012 Enacted	New emphasis is placed on elements in the portfolio that contribute to elucidating the underlying physics principles upon which concepts of toroidal confinement are based and to validating computational models.	11,000
2013 Request	EPR will examine a wide range of magnetic confinement configurations with an emphasis on establishing the scientific connections across concepts so as to help establish an experimentally validated predictive capability for magnetically confined fusion overall. An open solicitation for EPR proposals will be issued, resulting in a competitive, external peer review of all projects in the current portfolio.	10,500

High Energy Density Laboratory Plasmas

Overview

High Energy Density Laboratory Plasma (HEDLP) physics supports emerging scientific opportunities both in the basic science of HEDLP and also in Inertial Fusion Energy Science, strengthening U. S. leadership in this growing field of plasma science. FES investments in HEDLP science impact broad, cross-cutting research in areas ranging from laboratory astrophysics to materials under extreme conditions, as well as national security. The entry of new, cutting-edge facilities and capabilities in HEDLP science within the U.S., such as the National Ignition Facility (NIF) and the Matter in Extreme Conditions Instrument (MECI) at the SLAC Linac Coherent Light Source (LCLS), are enabling forefront discovery science.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	Through a joint program with NNSA, FES supported research activities on both small- and medium-scale facilities at universities, private industry, and DOE laboratories. This included facilitating user access to a range of HEDLP facilities, developing diagnostics and experimental platforms for general high energy density science, and supporting experimental, theoretical, and modeling efforts in discovery HEDLP science. Additionally, FES continued to support research in Inertial Fusion Energy Science, exploring the physics related to fast ignition, heavy-ion fusion, and magnetized high energy density plasmas.	25,727
2012 Enacted	FES and NNSA hold a joint solicitation, covering a breadth of HEDLP topics identified in both the FESAC and ReNeW reports on HEDLP, for the funding of three-year awards beginning in FY 2012. Additionally, funds are being provided for facility staff and research at the MECI.	24,741
2013 Request	FES will rebalance the HEDLP program, informed by the needs and opportunities identified in the FESAC report on scientific issues and opportunities in fundamental and mission-driven HEDLP. The decrease in the HEDLP budget will require a reassessment of priorities. Program specifics will be informed in part by the outcome of a competitive review of much of the program in FY 2012 and FY 2013 and the National Research Council (NRC) Inertial Fusion Energy (IFE) study report. The MECI will continue to be a high priority.	16,933

Madison Symmetric Torus

Overview

The Madison Symmetric Torus (MST) experiment at the University of Wisconsin-Madison focuses on the fundamental understanding of the physics of reversed field pinches, particularly magnetic fluctuations and their macroscopic consequences, and uses this understanding to develop the validation of theoretical models by experimental investigation. The reversed field pinch (RFP) configuration of the MST is geometrically similar to that of a tokamak, but with a much weaker externally applied magnetic field that reverses direction near the edge of the plasma. MST is the only RFP operating in the U.S., and is a world leader in reversed field pinch research. MST is also unique since it has pioneered the reduction of magnetic fluctuations by current density profile control. Research in the RFP's self-organization properties has astrophysical applications.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	A neutral beam injector was installed on the MST device. An assessment of the impact of the neutral beam on plasma flow, momentum transport, confinement of energetic ions, and plasma current profile was carried out. Measurements of the fast ion distribution function were made with a neutral particle analyzer.	7,005
2012 Enacted	The MST experiment continues with reversed field pinch-specific research activities. Measurements of the radial profile of fast ions created by neutral beam injection are made with a compact neutral particle analyzer. The MST team also designs a low-power antenna for characterizing plasma instabilities.	6,000
2013 Request	Planned research tasks include measurements of short-wavelength electron temperature fluctuations with the use of a fast Thomson scattering diagnostic. A low-power antenna to be installed in FY 2012 will enable the excitation and measurement of plasma instabilities. The MST team will also investigate momentum transport and dynamo effects and compare the experimental results against the predictions of extended magnetohydrodynamic codes.	5,750

Theory

Overview

The Theory program is focused on advancing the scientific understanding of the fundamental physical processes governing the behavior of magnetically confined plasmas. In addition to its scientific discovery mission, the Theory program is also responsible for providing the scientific grounding for and establishing limitations and ranges of applicability of the underlying physics models implemented in the SciDAC advanced simulation codes. Theorists in larger groups, located mainly at national laboratories and in private industry, generally support major experiments, work on large problems requiring a team effort, and tackle complex issues requiring multidisciplinary teams. Theorists at universities play a significant role in supporting innovative validation being carried out on smaller experiments and experimental platforms. They also work on fundamental problems in the plasma science of magnetic fusion and train the next generation of fusion plasma scientists.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	Areas of focus of the Theory program in FY 2011 included magnetohydrodynamics, confinement and transport, boundary physics, plasma heating and current drive, energetic particle effects, and atomic processes in fusion plasmas.	25,663
2012 Enacted	In FY 2012, the Theory program continues to focus on the plasma science of magnetic confinement. Among the areas emphasized are the elucidation of theoretical issues associated with the scientific foundations of the gyrokinetic theory, the development of improved models for major disruptions in tokamaks, continued studies of the interaction of radiofrequency fields with antenna surfaces and plasma, and the further understanding of the potential of 3-D magnetic perturbations for attaining improved confinement regimes in tokamak plasmas.	24,348
2013 Request	In FY 2013, funding is reduced and will result in a reduction of the number of projects at universities and national laboratories and a narrowing of the scope of the Theory program. Priority will be given to research relevant to burning plasmas, as well as to efforts leveraging the FES SciDAC portfolio. In addition, fewer projects may be selected for award during the annual theory solicitation.	20,836

SciDAC

Overview

The FES Scientific Discovery through Advanced Computing (SciDAC) program, which is part of the SC-wide SciDAC program, is aimed at advancing scientific discovery in fusion plasma science by exploiting leadership class computing resources and associated advances in computational science. The FES SciDAC portfolio contributes to the FES goal of advancing the fundamental science of magnetically confined plasmas to develop the predictive capability needed for a sustainable fusion energy source. In addition, the computational modules developed under the SciDAC program will become the building blocks of future large-scale integrated simulation efforts.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	During FY 2011, the five FES SciDAC Centers selected in 2010 began their research activities. FY 2011 was also the last year of funding for the three Fusion Simulation Prototype Centers, co-funded by FES and ASCR, which addressed multiphysics, code integration, and framework development issues in the areas of plasma boundary, control of magnetohydrodynamic (MHD) instabilities via radiofrequency (RF) methods, and the coupling of the core and edge regions of tokamak plasmas.	7,057
2012 Enacted	In FY 2012, the five FES SciDAC Centers continue advancing scientific discovery in fusion plasma science in the areas of microturbulence driven transport, macroscopic stability, the interaction of RF waves with plasmas, and the physics of energetic particles. New multi-institutional interdisciplinary Centers, co-funded by FES and ASCR, are added to the FES SciDAC portfolio in FY 2012, following the peer-review of the proposals submitted to the joint FES-ASCR SciDAC solicitation for *Scientific Computation Application Partnerships in Fusion Energy Science*.	8,312
2013 Request	In FY 2013, the FES SciDAC projects will continue focusing on problems of importance to burning plasmas. The five projects started in FY 2011 will be entering their third year of operation and will undergo a mid-term progress review. The reduction in funding in FY 2013 will necessitate the reduction of the level of support for all projects in the FES SciDAC portfolio, including those selected for an award in FY 2012.	6,556

General Plasma Science

Overview

The General Plasma Science (GPS) program focuses on fundamental issues of plasma science and engineering, complementing and reaching beyond burning plasma science into many basic and applied physics areas where improved understanding of the plasma state is needed. The major elements of this program include the NSF/DOE Partnership in Basic Plasma Science and Engineering at universities, general plasma science at the DOE laboratories, NSF/DOE support of the Basic Plasma Science Facility at the University of California at Los Angeles (UCLA), DOE Laboratory collaborations for the NSF Center for Magnetic Self-Organization (CMSO) in Laboratory and Astrophysical Plasmas, and the Plasma Science Center (PSC) program. GPS scientific research activities include fundamental activities (dynamical complexity, turbulence, inhomogeneity, magnetic reconnection, wave-particle interactions, relativistic effects, strong interparticle coupling, and nonlocal effects) and also multidisciplinary activities (low-temperature plasmas; astrophysical plasmas; heliospheric plasmas; neutral, dusty, and anti-matter plasmas; multi-phase plasmas; biologically and industrially relevant plasmas; and space-plasma-related laboratory experiments). These activities take place at universities and at DOE laboratories, mostly in individual-investigator research groups, but also in large groups associated with multi-institutional plasma science centers.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	GPS activities continued with the annual solicitation of the successful NSF/DOE Partnership in Basic Plasma Science and Engineering, FES participation in the CMSO via funding of the DOE laboratory collaborators, the Basic Plasma Science Facility at UCLA, and PSCs. Two PSCs were funded (one through 2013 and another through 2011) by the ARRA funding, and regular appropriations funding was provided for a third PSC continuation.	14,810
2012 Enacted	The major elements of the GPS program are continued. The Oak Ridge National Laboratory Atomic Data Center experimental atomic physics program is closed out. Two PSCs are continued, and laboratory basic plasma activities are expanded.	16,780
2013 Request	The support for Plasma Science Centers and laboratory general plasma science will be decreased. An open competition for GPS research at the DOE laboratories is planned in order to maintain program balance through competitive peer review. Support for the NSF/DOE Partnership will be maintained.	13,151

Facility Operations
Funding Profile by Activity

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
DIII-D	35,699	38,319	33,260
Alcator C-Mod	17,518	18,067	7,848
NSTX	32,559	32,134	29,393
Other, GPE, and GPP	4,568	975	975
MIE: U.S. Contributions to ITER Project	80,000	105,000	150,000
Total, Facility Operations	170,344	194,495	221,476

Overview

The Facility Operations subprogram mission is to provide for required plasma diagnostics, operation, maintenance, and minor modifications at the major U.S. fusion user facilities, to carry out major upgrades to existing facilities when necessary, and to construct new facilities such as ITER to advance progress toward a fusion energy source. The current major experimental facilities in the FES program—the DIII-D tokamak at General Atomics in San Diego, California; the Alcator C-Mod tokamak at MIT in Cambridge, Massachusetts; and NSTX at the Princeton Plasma Physics Laboratory (PPPL) in Princeton, New Jersey—provide the tools for the U.S. and international research community to explore and solve fundamental issues of fusion plasma physics and to address a subset of the materials science issues required to manage the intense heat and particle fluxes of a fusion reactor. All three are operated as national collaborative facilities and involve users from many laboratories, industries, and universities. The support for these activities is balanced to ensure safe operation of each facility; provide modern experimental tools such as heating, fueling, and exhaust systems; and provide the operating time to meet the needs of scientific collaborators in order to conduct world-class innovative research. ITER, presently under construction in Cadarache, France by an international team, is designed to be the first magnetic fusion facility to achieve self-sustaining, or burning, plasmas and will thus open a new era in fusion energy science.

Explanation of Funding Changes

Several major program changes in this area will provide a challenge to facility operations in FY 2013. As ITER construction activities continue to ramp up, efficient management of the U.S. contributions to the international project by the U.S. ITER Project Office (USIPO) at Oak Ridge National Laboratory (ORNL) will be a high priority for FES. In addition, NSTX will not operate in FY 2013 while the effort at that facility is focused on completing the upgrade by FY 2015. To provide funding for higher priority program elements, the Alcator C-Mod facility will be shut down in FY 2013. The C-Mod research staff will begin a transition to collaborative research activities on other experiments, both domestic and international. As these transitions occur in FY 2013, the DIII-D tokamak will be the only major operating fusion experiment in the U.S.; consequently, there may be increased pressure for research time on that device.

	(Dollars in Thousands)		
	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 20112
DIII-D	38,319	33,260	-5,059
The funding reduction will halt all major facility upgrades and defer system refurbishments, but still allow for 10 weeks of operation in FY 2013.			
Alcator C-Mod	18,067	7,848	-10,219
The Alcator C-Mod facility is shut down in FY 2013. No operations will be conducted and the funding will provide for the safe shutdown of the facility.			
NSTX-U	32,134	29,393	-2,741
Overall funding for NSTX Facility Operations and NSTX-U Major Item of Equipment (MIE) is decreased. Within this combined funding, priority is given to the NSTX-U MIE project so that it can be completed by the September 2015 target date. The MIE project will enhance the capabilities of NSTX by upgrading the magnet system to permit higher plasma currents and magnetic fields and by installing a second neutral beam heating system to enable better control of plasma stability.			
U.S. Contributions to ITER Project (MIE)	105,000	150,000	+45,000
The funding increase for the U.S. contributions to the ITER project will enable the U.S. to make long-lead procurements as the project enters its construction period.			
Total Funding Change, Facility Operations	194,495	221,476	+26,981

DIII-D

Overview

The DIII-D tokamak is the largest magnetic fusion research experiment in the U.S. and can magnetically confine plasmas at close to temperatures relevant to burning plasma conditions. Researchers from the U.S. and abroad are able to perform experiments on DIII-D to study stability, confinement, and other properties of fusion-grade plasmas under a wide variety of conditions. The DIII-D national research program mission is to establish the scientific basis for the optimization of the tokamak approach to fusion energy production. DIII-D has considerable experimental flexibility and also extensive world-class diagnostic instrumentation to measure the properties of high-temperature plasmas. Characteristics of the facility include a highly flexible field-shaping coil system to produce a wide variety of plasma shapes, all-carbon plasma-facing material, coil sets both inside and outside the vacuum vessel which are used to correct error fields and study the plasma response to perturbing magnetic fields, a broad range of auxiliary heating and current drive systems, over 50 state-of-the-art diagnostic systems to examine plasma parameters, and an advanced digital control system for feedback control of the plasma.

DIII-D is an established facility for developing long-pulse, high performance advanced tokamak operating scenarios. Its extensive plasma diagnostics set and its coupling to theoretical and computational studies are contributing substantially to resolution of ITER physics design issues and preparations for burning plasma research. DIII-D has been a major contributor to the world fusion program over the past two decades.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	In March 2011, DIII-D completed a 12-month Long Torus Opening for major facility modifications and upgrades. In addition to several diagnostic system upgrades, one of the four neutral beam heating systems was successfully modified to inject power off the central axis of the plasma by being tilted upward at an angle from 0 to 16.5 degrees. Work also continued to upgrade the microwave auxiliary heating system as part of an ARRA-funded task. In the second half of FY 2011, the tokamak operated for 14 weeks to conduct planned experiments.	35,699
2012 Enacted	After a few weeks of operation in October 2011, the facility entered a 4-month maintenance and upgrade period. During this time the ARRA upgrade to the microwave heating system is completed, adding a 7th high-power microwave tube (gyrotron) to the existing set of 6 operating tubes. An advanced infrared/visible viewing system (periscope) is installed in this time frame. Research operations are conducted in the second half of FY 2012 to complete the planned total of 13 weeks for the year.	38,319
2013 Request	Funding reductions mandate that additional facility upgrades and refurbishments will be deferred. DIII-D will conduct 10 weeks of research operations in FY 2013 to address the highest-priority ITER and advanced tokamak issues.	33,260

Alcator C-Mod

Overview

The Alcator C-Mod tokamak is a compact high-field device whose mission is to establish the plasma physics and plasma engineering basis for a burning plasma experiment and for a future fusion power plant. It is unique in that it has operated at and above the ITER design values for magnetic field and plasma density. Also it produces the tokamak plasma with the highest pressure in the world, approaching the pressures expected in a burning plasma. The high field makes up for its small size to achieve performance found in much larger tokamaks. It is unique in possessing all-metal walls and has heat fluxes approaching those projected for ITER. It has an extensive diagnostic set, as well as radiofrequency (RF) auxiliary heating and current drive systems.

C-Mod's compact size and high field make it important to dimensionless scaling studies relevant to ITER and eventually to fusion reactors. It has contributed to research on plasma wall interactions and RF wave heating.

The Alcator C-Mod facility is planned to be shut down in FY 2013, one year prior to the ending date of the current cooperative agreement for facility operations and research. The shutdown will enable support for higher-priority research areas in the U.S. fusion program while the C-Mod research staff makes the transition to collaborative activities.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	At the beginning of FY 2011, C-Mod conducted just over 14 weeks of research operations, utilizing an advanced lower hybrid (LH) launcher to study LH wave heating and current drive physics. During the summer maintenance vent an advanced ion cyclotron RF antenna (partially supported with ARRA funding) aligned to the C-Mod magnetic field structure was installed.	17,518
2012 Enacted	Research operations continue at the beginning of FY 2012 with the use of the new advanced ion cyclotron RF antenna. New fast ferrite tuners (funded by the ARRA) are installed on three RF transmitters to allow for more efficient power coupling to the plasma. A total of 17 weeks of research operations is planned for FY 2012.	18,067
2013 Request	In FY 2013 the C-Mod facility will be shut down. Systems will be disconnected, dismantled, and made available for use by other U.S. research facilities. No research operations are planned.	7,848

NSTX

Overview

NSTX is an innovative fusion science facility at PPPL based on a spherical torus (ST) confinement configuration. A major advantage of this configuration is the ability to confine a plasma with pressure that is high compared to the magnetic field energy density. Research on this configuration could lead to the development of smaller, more economical future fusion research facilities. It enables first-of-a-kind access to plasma parameters of high scientific relevance both to fusion and also to the astrophysical sciences.

A major upgrade to NSTX is currently under way. This NSTX-Upgrade MIE project consists of the installation of a new magnet center stack and the addition of a second neutral beam injection system. The new center-stack will double the magnetic field and plasma current, while increasing the plasma pulse length from about 1 second at 0.5 Tesla to 5 seconds at 1 Tesla, making NSTX the world's highest-performance ST. The second neutral beam system will double the heating power. This will make it possible to achieve higher plasma pressure and provide improved neutral beam current drive efficiency and current profile control, which is needed for achieving fully non-inductive operation. Together these upgrades will enable improved understanding of the ST magnetic confinement configuration, which is required to establish the physics basis for next-step ST facilities, broaden the scientific understanding of plasma confinement, and maintain U.S. world leadership in ST research. Controllable fully-non-inductive current-drive will also contribute to assessing the ST as a potentially cost-effective path to fusion energy.

The total project cost (TPC) baseline of $94,300,000 was approved at Critical Decision-2 (CD-2) in December 2010, and CD-3 approval to start fabrication was achieved in December 2011. Project completion is anticipated in 2015. The shutdown for the upgrade had been scheduled to begin in mid-FY 2012; however, a magnet coil failure at the end of FY 2011 led to a decision to accelerate the schedule and start the upgrade at the beginning of FY 2012.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	In FY 2011, 14 weeks of operation were planned, of which 4 weeks were completed at the beginning of the fiscal year and 10 were to be completed following a 7-month shutdown in the middle of the fiscal year to install a number of diagnostic and facility upgrades. During integrated systems testing in July 2011 to prepare for the final 10 weeks of operation, an arc occurred in the main magnetic field coils, causing damage. A detailed investigation revealed that the coils could not be repaired and that it would take up to 12 months to fabricate replacement coils. The NSTX team recommended and DOE approved starting the NSTX Upgrade project ahead of schedule. NSTX upgrade activities included decontamination of the second neutral beam, which was originally used on the now-completed Tokamak Fusion Test Reactor experiment, the review of the project final design, and the initiation of long-lead procurements and fabrications.	32,559
2012 Enacted	$15,004,000 of the total amount supports maintenance and repairs on all of the systems that are not involved in the upgrade project. NSTX Upgrade activities include initiating machine disassembly, continuing refurbishment of the neutral beam, and continuing component fabrication and assembly including the machining of the toroidal field inner coils.	32,134
2013 Request	NSTX will be shut down for the upgrade during FY 2013. Operations funding of $6,593,000 will support continued maintenance and repairs of all systems not involved in the upgrade project. NSTX Upgrade activities will include fabrication of the center stack, installation of new cable runs for the new center stack assembly, installation of new racks for diagnostic instrumentation, and completion of the refurbishment of the second neutral beam and its move into the test cell.	29,393

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
NSTX Operations	22,859	15,004	6,593
NSTX Upgrade (MIE)	9,700	17,130	22,800
Total	32,559	32,134	29,393

Other, GPE, and GPP

Overview

Funding for GPE, GPP, and Other provides support for general infrastructure repairs and upgrades for the PPPL site, based upon quantitative analysis of safety requirements, equipment reliability, research needs, and environmental monitoring needs.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	Upgraded various fire escapes; replaced C-Site underground chilled water service piping, C-Site Motor Generator (MG) Building roof (using funds from recycling the materials from C-Site MG demolition), Lyman Spitzer Building roof, and Plasma Physics Lab Computer Center roof; installed a boiler burner control upgrade; and performed environmental monitoring.	4,568
2012 Enacted	An uninterruptable power supply in the Lyman Spitzer Building computer room and control room stations, new window assemblies in the 2nd floor of the Laboratory Building, and cafeteria courtyard drainage modifications are installed. Environmental monitoring needs are supported. Due to the use of ARRA funding to improve PPPL's infrastructure during FY 2010–2011, the GPP funding need is reduced in FY 2012.	975
2013 Request	Funding will upgrade the chilled water system and various fire alarm systems and will support environmental monitoring needs.	975

U.S. Contributions to ITER Project (MIE)

Overview

The ITER Project aims to build a research facility capable of generating the world's first sustained (300 seconds, self-heating) burning plasma. The research on ITER will be aimed at assessing the scientific and technical feasibility of fusion energy. The ITER Project is being designed and built by an international consortium consisting of the U.S., China, India, Japan, South Korea, the Russian Federation, and the European Union (which is the host). The U.S. construction contribution of 9.09% will give the U.S. access to 100% of the research results from ITER. The objective of the U.S. ITER Project is to deliver the U.S. contributions to the project consisting of in-kind hardware components, personnel, and funding to the ITER Organization (IO) for the ITER construction phase per the terms of the ITER Joint Implementation Agreement. The U.S. ITER Project is managed by the U.S. ITER Project Office (USIPO) and is located at Oak Ridge National Laboratory (ORNL). The USIPO partners with the Princeton Plasma Physics Laboratory and Savannah River National Laboratory. Each laboratory has been assigned a defined portion of the project's scope that takes advantage of their respective technical strengths. Under DOE's direction, the USIPO is responsible for planning, managing, and delivering U.S. commitments to ITER. All U.S. ITER Project activities are overseen by a DOE Federal Project Director at the DOE Oak Ridge Office. The IO is responsible for specifying top-level hardware design requirements and delivery schedules, as the design agent and eventual ITER facility operator.

The U.S. ITER Project was formally initiated in July 2005 when Critical Decision-0 (CD-0), Mission Need, was approved. The first year of project funding was FY 2006. CD-1, Alternatives Selection and Cost Range (including authorization for long-lead procurements), was approved in January 2008, setting the preliminary Total Project Cost (TPC) range at $1.45 to $2.2 billion (as spent). The Administration is monitoring the projected costs of the U.S. ITER Project closely. It is possible that costs will increase beyond the CD-1 cost range. An independent cost review is scheduled to be conducted in the spring of FY 2012 in parallel with the Department's own review of costs and activities of this undertaking as the U.S. ITER project baseline proposal is developed and reviewed for CD-2.

The U.S. remains committed to the scientific mission of ITER, while maintaining a balanced research portfolio, and will work with ITER partners to accomplish this goal. Current efforts are focused on completing U.S. hardware component designs and the supporting R&D, the majority of which will be completed by the end of FY 2012. The USIPO has also begun long-lead procurements for certain critical path items. The $150,000,000 funding for the U.S. ITER Project in FY 2013 is a reflection of the accelerated pace of ITER construction starting in mid-2011, which will require the placement of significant new procurement contracts with U.S. suppliers and the commencement of in-kind component fabrication. The majority of the U.S. contributions to the ITER Project (MIE) will be spent on in-kind hardware sourced from U.S. industries, national laboratories, and universities.

The Administration's prior initiatives to implement management reforms at the IO and accelerate ITER construction are taking effect. The new management team under the Director General has worked to minimize the overall cost of the construction phase for the U.S. and the other ITER Members.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	The USIPO continued its efforts toward U.S. contributions to the ITER Project. The USIPO awarded a contract for the Central Solenoid, representing around 8% of the U.S. in-kind commitment, to General Atomics in San Diego, California. The USIPO worked to complete design specifications and improve cost estimates on the entire U.S. in-kind scope in preparation for CD-2. These activities are being closely coordinated through the IO and in conjunction with the other ITER Members.	80,000

Fiscal Year	Activity	Funding ($000)
2012 Enacted	The 2012 appropriation supports design activities and placement of initial contracts for the U.S. contributions to ITER construction. These contracts include approved long-lead procurements such as the tokamak cooling water system and the steady-state electrical network, which are key critical-path items for ITER. The USIPO also aims to complete the prerequisite activities required for gaining CD-2 approval.	105,000
2013 Request	Fabrication activities ($89,000,000), mostly performed by U.S. companies, will continue for ongoing U.S. systems. The USIPO will continue work toward completion of designs for several key U.S. systems. The U.S. will provide a cash contribution to the project in accordance with the ITER Organization (IO) budget request ($31,000,000). The U.S. remains committed to the scientific mission of ITER, while maintaining a balanced research portfolio and will work with ITER partners to accomplish this goal.	150,000

Enabling R&D
Funding Profile by Activity

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Plasma Technology	14,501	13,911	11,666
Advanced Design	2,752	4,337	1,611
Materials Research	6,469	7,729	9,371
Total, Enabling R&D	23,722	25,977	22,648

Overview

The Enabling R&D subprogram helps the Science subprogram address scientific challenges by developing and continually improving the hardware, materials, and technology that are incorporated into existing fusion research facilities, thereby enabling these facilities to achieve higher levels of performance and increased flexibility for critical tests of plasma heating and stability. Enabling R&D also supports the development of new hardware, materials, and technology that are incorporated into the design of next-generation fusion science facilities, thereby increasing confidence that the predicted performance of these new facilities will be achieved. Major activities include development of the technologies to heat, fuel, confine, and control the plasma and of the materials inside the plasma chamber, including structural, plasma-facing, and blanket materials, as well as safety research and system studies that help guide the program's future. In FY 2013, the primary Enabling R&D emphasis is to address the materials and nuclear science issues that will be encountered as fusion science moves into the burning plasma era.

Explanation of Funding Changes

The funding changes reflect the need to address the significant challenges in the materials and nuclear science areas that must be dealt with as fusion moves into the burning plasma era and advances towards its realization as a future energy source.

	(Dollars in Thousands)		
	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Plasma Technology	13,911	11,666	-2,245
The level of support for advanced technologies for future facilities will be reduced.			
Advanced Design	4,337	1,611	-2,726
The level of support for design studies of future facilities and for the Virtual Laboratory for Technology (VLT) will be reduced.			
Materials Research	7,729	9,371	+1,642
The funding increase will support upgrades to experimental facilities; development of joining technologies; modeling; and research on nano-composited high strength structural and plasma-facing materials and other fusion-chamber materials.			
Total Funding Change, Enabling R&D	25,977	22,648	-3,329

Plasma Technology

Overview

The Plasma Technology program develops enabling technologies such as those necessary to heat, fuel, and confine the plasma, to breed and process the deuterium and tritium fuel, to protect the interior surface of the plasma chamber from the harsh fusion environment, and to assure that fusion facilities are operated in a safe and environmentally responsible manner. This program element supports both current and potential future domestic experiments and frequently plays a significant part in our international collaboration activities, including those that address potential ITER operational issues through the development of tools that will allow assessment and resolution of critical scientific issues.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	In FY 2011, the Plasma Technology program supported research on developing magnets utilizing high temperature superconductors; improving the efficiency of the gyrotron and transmission line components for plasma heating; developing techniques to address the mitigation of edge localized modes that can potentially damage the plasma-facing components; conducting experimental and modeling activities that support both liquid and solid breeding blanket research; developing a better understanding of tritium accumulation and improving material performance in plasma facing components; and developing better and more accurate analytical tools for safety analysis.	14,501
2012 Enacted	Efforts identified above continue, as well as efforts addressing issues of tritium-materials interaction in the ITER mixed material environment of tungsten-carbon-beryllium. Also a series of material science experiments under a U.S.-Japan collaborative program on plasma facing and blanket materials for use in future facilities continues.	13,911
2013 Request	Efforts identified above will continue, but at a reduced level. In addition, the program will focus on completing the last series of tritium-materials interactions experiments as part of the U.S.-Japan collaborative program on plasma facing and blanket materials for use in future facilities.	11,666

Advanced Design

Overview

Advanced Design funding supports pre-conceptual studies of potential fusion power plants based on the various confinement approaches currently being considered in the fusion research program. These studies help to identify the various scientific challenges to fusion energy. In addition, this program element provides support for the Virtual Laboratory for Technology (VLT), an organization that serves to coordinate fusion technology research at universities and labs throughout the country.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	In FY 2011, the first year of a three year systems-level study was begun to determine the advances that are needed in the plasma-materials interface (PMI) sciences area, including the issues associated with plasma control. Preliminary scoping efforts and development of a consistent set of parameters for a single-point design effort for tokamaks were completed.	2,752
2012 Enacted	In FY 2012 funding continues the study of PMI issues through the further development of a consistent point design of a tokamak facility that will address the PMI issues for commercial-sized fusion power plants.	4,337
2013 Request	By late FY 2013, the current study of the systems level issues associated with PMI and plasma control will be completed. The final report will be written, and the results distributed by way of presentations at the appropriate conferences. During FY 2013, a broad effort will be initiated to develop options for the next study.	1,611

Materials Research

Overview

The Materials Research program supports the development, characterization, and modeling of materials used in the fusion environment, which is extremely harsh in terms of both temperature and irradiation. Having materials that can withstand this environment under the long-pulse or steady-state conditions anticipated in future fusion experiments is essential. A strong materials program is needed in order to aid in the development of materials that can withstand these demanding conditions. The Materials Research program focuses on structural, plasma-facing, and blanket materials.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	In FY 2011, the Materials Research program investigated the response of tungsten, steel, and silicon carbide composite materials to irradiation and the generation of helium bubbles on bulk properties, showing how the microstructure of the material changed as a result of irradiation, temperature, and helium bubble formation. Models were used to help explain the data, as well as predict how the microstructure of the material could be changed in order to lessen the damage.	6,469
2012 Enacted	In FY 2012, funding is continued for R&D activities dedicated to structural, plasma-facing, and blanket materials and joining technologies. The focus is on the effects of helium bubble and void generation in materials, neutron irradiation damage, and predictive simulation codes. Tungsten, reduced activation ferritic/martensitic steels, nanostructured ferritic alloys, oxide dispersion strengthened steels, and silicon carbide composites are being investigated.	7,729
2013 Request	In FY 2013, funding will continue for R&D dedicated to structural, plasma-facing, and blanket materials and joining technologies. Design studies aimed at the eventual fabrication of component systems and possible new experimental facilities with increasingly relevant fusion conditions will be started. The fundamental scientific understanding garnered through FY 2012 will be utilized for initial design of components, systems, and fabrication and joining technologies, emphasizing an integrated approach, as opposed to studying individual materials in isolation.	9,371

Supporting Information

Operating Expenses, Capital Equipment and Construction Summary

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Operating Expenses	281,707	275,672	233,240
Capital Equipment	82,137	124,859	164,619
General Plant Projects	3,413	465	465
Total, Fusion Energy Sciences	367,257	400,996	398,324

Funding Summary

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Research	196,913	206,501	176,848
Scientific User Facility Operations	76,076	71,390	47,701
Major Items of Equipment	89,700	122,130	172,800
Other (GPP, GPE, and Infrastructure)	4,568	975	975
Total, Fusion Energy Sciences	367,257	400,996	398,324

Scientific User Facilities Operations and Research

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
DIII-D			
Operations	35,699	38,319	33,260
Facility Research	30,716	30,300	26,703
Total DIII-D	66,415	68,619	59,963
Alcator C-Mod			
Operations	17,518	18,067	7,848
Facility Research	10,056	10,454	8,396
Total Alcator C-Mod	27,574	28,521	16,244

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
NSTX			
Operations	22,859	15,004	6,593
Facility Research	16,107	17,549	16,836
Total NSTX	38,966	32,553	23,429
Scientific User Facilities Operations and Research			
Operations	76,076	71,390	47,701
Facility Research	56,879	58,303	51,935
Total, Scientific User Facilities Operations and Research	132,955	129,693	99,636

Facility Hours and Users

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
DIII-D National Fusion Facility			
Achieved Operating Hours	578	N/A	N/A
Planned Operating Hours	560	520	400
Optimal Hours	1000	1,000	1000
Percent of Optimal Hours	58%	52%	40%
Unscheduled Downtime Hours	51	N/A	N/A
Number of Users	235	230	200
Alcator C-Mod			
Achieved Operating Hours	464	N/A	N/A
Planned Operating Hours	480	544	0
Optimal Hours	800	800	0
Percent of Optimal Hours	58%	68%	0%
Unscheduled Downtime Hours	24	N/A	N/A
Number of Users	188	194	100

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
National Spherical Torus Experiment			
Achieved Operating Hours	168	N/A	N/A
Planned Operating Hours	560	0	0
Optimal Hours	1,000	0	0
Percent of Optimal Hours	17%	N/A	N/A
Unscheduled Downtime Hours	400	N/A	N/A
Number of Users	145	145	85
Total, Facilities Hours and Users			
Achieved Operating Hours	1210	N/A	N/A
Planned Operating Hours	1,600	1,064	400
Optimal Hours	2,800	1,800	1,000
Percent of Optimal Hours	43%	59%	40%
Unscheduled Downtime Hours	475	N/A	N/A
Number of Users	568	569	385

Major Items of Equipment (MIE)

(Dollars in Thousands)

	Prior Years	FY 2011 Current	FY 2012 Enacted	FY 2013 Request	Outyears	Total	Completion
NSTX Upgrade							
TEC	3,550	9,700	17,130	22,800	30,485	83,665	4Q FY 2015
OPC	10,635	0	0	0	0	10,635	
TPC	14,185	9,700	17,130	22,800	30,485	94,300	
ITER							
TEC	304,366	67,000	104,930	140,965	TBD	TBD	TBD
OPC	60,019	13,000	70	9,035	TBD	TBD	
TPC	364,385	80,000	105,000	150,000	TBD	TBD	
Total MIEs							
TEC		76,700	122,060	31,835			
OPC		13,000	70	140,965			
TPC		89,700	122,130	172,800			

Facility Operations MIEs:

National Spherical Torus Experiment Upgrade Major Item of Equipment Project. The NSTX Upgrade Project supports major upgrades at NSTX to keep its world-leading status. This project will add a new center stack magnet assembly that will double the magnetic field, and a second neutral beam (NB) system that will double the

NB power available to heat the plasma. CD-0 (Approve Mission Need) was completed on February 23, 2009. The CD-1 (Approve Alternative and Cost Range) was completed on April 15, 2010. CD-2 (Approve Performance Baseline) was achieved on December 20, 2010. The performance baseline for the MIE project is $94,300,000 with completion in September 2015. CD-3 (Start of Construction/Execution) was approved in December, 2011. As discussed in the Science and Facility Operations subprograms, NSTX will be shut down in FY 2012 and FY 2013 so that the upgrade can proceed. In FY 2013, PPPL will focus on continuing major fabrication of components for the center stack magnet assembly and neutral beam upgrades.

U.S. Contributions to ITER. The U.S. Contributions to ITER Project fund the U.S. 9.09% in-kind and cash contributions to the international ITER Project, as agreed to under the ITER Joint Implementation Agreement. The seven Members of ITER along with the ITER Organization will build, operate, and decommission this cooperative project. The Project is in the early phase of construction.

Scientific Employment

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
# University Grants	307	310	280
# Laboratory Projects	171	175	160
# Permanent Ph.D's (FTEs)	760	760	675
# Postdoctoral Associates (FTEs)	116	115	90
# Graduate Students (FTEs)	335	325	263
# Ph.D.'s awarded	42	42	42

High Energy Physics
Funding Profile by Subprogram with Activity

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Proton Accelerator-Based Physics			
Research	135,128	122,894	125,394
Facilities	303,727	298,700	286,138
Total, Proton Accelerator-Based Physics	438,855	421,594	411,532
Electron Accelerator-Based Physics			
Research	14,645	12,550	13,946
Facilities	9,809	10,475	15,200
Total, Electron Accelerator-Based Physics	24,454	23,025	29,146
Non-Accelerator Physics			
Research	70,355	69,562	70,962
Projects	19,712	14,500	26,463
Total, Non-Accelerator Physics	90,067	84,062	97,425
Theoretical Physics			
Research			
Grants Research	27,423	28,222	29,072
National Laboratory Research	25,638	23,778	24,501
Computational HEP	10,842	10,963	10,963
Other	4,147	3,887	3,986
Total, Theoretical Physics	68,050	66,850	68,522
Advanced Technology R&D			
Accelerator Science	42,104	44,150	46,850
Accelerator Development	86,801	75,400	52,600
Other Technology R&D	25,247	27,739	29,856
SBIR/STTR	0	20,040	20,590
Total, Advanced Technology R&D	154,152	167,329	149,896
Subtotal, High Energy Physics	775,578	762,860	756,521

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Construction			
Long Baseline Neutrino Experiment	0	4,000	0
Muon to Electron Conversion Experiment	0	24,000	20,000
Total, Construction	0	28,000	20,000
Total, High Energy Physics	775,578[a]	790,860[b]	776,521

[a] Total is reduced by $19,842,000: $17,716,000 of which was transferred to the Small Business Innovation and Research (SBIR) program and $2,126,000 of which was transferred to the Small Business Technology Transfer (STTR) program.
[b] The FY 2012 appropriation is reduced by $840,000 for the High Energy Physics share of the DOE-wide $73,300,000 rescission for contractor pay freeze savings. The FY 2013 budget request reflects the FY 2013 impact of the contractor pay freeze.

Public Law Authorizations

Public Law 95–91, "Department of Energy Organization Act", 1977
Public Law 109–58, "Energy Policy Act of 2005"
Public Law 110–69, "America COMPETES Act of 2007"
Public Law 111–358, "America COMPETES Act of 2010"

Program Overview and Benefits

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

At the same time, the new technologies created to answer the questions that high energy physicists seek to answer, and the knowledge acquired in their pursuit, also yield substantial benefits of a more tangible nature for society as a whole. The discovery of x-rays was driven not by surgeons in search of a better way to diagnose bone fractures but by scientists engaged in basic research. The Standard Model of particle physics, first established in the 1970s, describes the behavior of elementary particles and forces, often to very high precision. Nevertheless, the Standard Model fails at the high energies now being created in particle accelerators and describes only normal visible matter—only about 5% of the universe. The remaining 95% of the universe consists of "dark" matter and energy whose fundamental nature remains a mystery.

A world-wide program of particle physics research is underway to explore what lies beyond the Standard Model. To this end, HEP supports a program focused on three scientific frontiers:

- *The Energy Frontier,* creating new particles, revealing their interactions, and investigating fundamental forces;
- *The Intensity Frontier,* investigating fundamental forces and particle interactions by studying events that rarely occur in nature; and
- *The Cosmic Frontier,* making measurements offering new insight and information about the nature of dark matter and dark energy to understand fundamental particle properties and discover new phenomena.

Together, these complementary discovery frontiers offer the opportunity to answer some of the most basic questions about the world around us:

- *Are there undiscovered principles of nature, such as new symmetries or new physical laws?*

  The laws of quantum physics that describe elementary particles and forces are based on underlying symmetries of nature. Some of these symmetries prevail only at very high energies. A possible new symmetry, called supersymmetry, relates particles and forces. It predicts a superpartner for every particle currently known. The search for such superparticles will be carried out with experiments at the Energy Frontier or indirectly with measurements at the Intensity or Cosmic Frontiers.

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

  The structure of the universe today is a result of two opposing forces: gravitational attraction and cosmic expansion. For approximately the last six billion years, the universe has been expanding at an accelerating rate due to a mysterious dark energy that overcomes gravitational attraction. The existence of dark energy was first proposed in 1998 to explain observations made by HEP-supported researchers (among others). More and other types of data, gathered from the Cosmic Frontier, along with new theoretical ideas, are necessary to make progress in understanding its fundamental nature.

- *Are there extra dimensions of space?*

  String theory is an attempt to unify physics by explaining particles and forces as the vibrations of sub-microscopic strings. String theory predicts that space has more than three dimensions, although the extra ones are too small to be observed directly. Experiments at the Energy Frontier may find evidence for extra dimensions, requiring a completely new paradigm for thinking about the structure of space and time.

- *Do all the forces become one?*

  All the basic forces in the universe could be various manifestations of a single unified force. Unification was Einstein's great, unrealized dream and advances in string theory give hope of achieving it. The discovery of superpartners or extra dimensions at Energy Frontier accelerators, or hints of them at the Intensity or Cosmic Frontiers, would lend strong support to current ideas about unification.

- *Why are there so many kinds of particles?*

  Three different pairings, or families, of quarks and leptons have been discovered. Does nature somehow require that there are only three families, or are there more? The various quarks and leptons also have widely different masses and force couplings. These differences suggest there may be an undiscovered explanation that unifies quarks and leptons. Detailed studies that employ Energy Frontier accelerators, as well as precision measurements made at Intensity Frontier facilities, may provide dramatic insights into this complex puzzle.

- *What is dark matter?*

  Astronomical data suggest that most matter in the universe is unseen. We know of its existence only through its gravitational interactions with normal matter. This dark matter is thought to consist of exotic particles (relics) that have survived since the Big Bang. Experiments are being mounted to try to directly detect these exotic particles via observations of relic dark matter at the Cosmic Frontier or by producing them at Energy Frontier accelerators that briefly recreate the conditions of the Big Bang.

- *What are neutrinos telling us?*

  Of all the known particles, neutrinos are perhaps the most enigmatic and certainly the most elusive. The three known varieties of neutrinos were all discovered by HEP researchers working at U.S. facilities. Many trillions of neutrinos can pass through an area the size of a postage stamp every second with little or no interaction. Their detection requires intense neutrino sources and large detectors. HEP supports research into fundamental neutrino properties because they may reveal important clues to the unification of forces and the very early history of the universe.

- *How did the present universe come to be?*

  The universe began with a massive explosion known as the Big Bang followed by a burst of expansion of space itself. The universe then expanded more slowly and cooled, which allowed the formation of stars, galaxies, and ultimately life. Understanding the very early evolution of the universe will require a breakthrough in physics: the theoretical reconciliation of quantum mechanics with gravity.

- *What happened to the antimatter?*

  The universe appears to contain very little antimatter. Antimatter is continually produced by naturally occurring nuclear reactions only to undergo near immediate annihilation. The Big Bang, however, should have produced equal amounts of both matter and antimatter, which agrees with the study of high-energy collisions in the laboratory. Precise Intensity Frontier measurements of the subtle asymmetries present in the weak nuclear interaction may shed light on how the present day matter-antimatter asymmetry arose.

The strong connections between these key questions necessitates coordinated initiatives across the frontiers. HEP invents new technologies to answer these questions and to meet the challenges of research at the frontiers. HEP supports theoretical and experimental studies by individual investigators and large collaborative teams—some who gather and analyze data from accelerator facilities in the U.S. and around the world, and others who develop and deploy ultra-sensitive instruments to detect particles from space and observe astrophysical phenomena that advance our understanding of fundamental particle properties.

The continuous improvement of accelerator and detector technology necessary to pursue high energy physics as well as the scale of the science itself, have had transformative impacts on the Nation's economy, security, and society. HEP, as the primary steward of accelerator science and advanced accelerator technology R&D in the Office of Science, has developed the knowledge and technologies that are the basis of Office of Science major accelerator user facilities. HEP's contributions to the underlying technologies now used in medicine, science, industry, and national security are also well known. HEP coordinates accelerator research investments with the Basic Energy Sciences (BES) and Nuclear Physics (NP) programs and will expand its coordination role in FY 2013.

HEP's ongoing and future development of accelerator, detector, electronics, and magnet technologies is anticipated to have significant impact in a number of areas:

- homeland and national security—particle accelerators and detectors are increasingly valuable for hazardous material detection and non-proliferation verification;
- industry—superconducting cables being developed for next generation magnets could be used to transmit, with minimal power losses, far more electricity than conventional cables;
- internet grid development—development of grid capability for analysis of Large Hadron Collider (LHC) data may result in a paradigm change in the handling of huge data sets; and
- medical treatment and diagnosis—more cost-efficient particle accelerators, detectors, and magnets for cancer treatment and diagnosis should emerge.

Basic and Applied R&D Coordination

Many broader applications of technology developed by HEP research have been unforeseen. In order to obtain guidance on how to better bridge the gap between accelerator research and technology deployment, HEP held an "Accelerators for America's Future" symposium in October 2009, followed by a two-day workshop where more than 100 experts familiar with accelerator needs and requirements met to identify technological and policy issues that, if overcome, could have transformative impacts in the areas of national security, medicine, energy and environment, industry, and discovery science (including accelerator science).

The report from this workshop[a] identifies possible future applications of accelerators, as well as key technical areas where focused additional R&D efforts as well as dedicated user and demonstration facilities would advance the broad beneficial uses of accelerators in society. HEP will use the workshop report to develop a strategic plan for accelerator technology R&D in collaboration with BES and NP that recognizes its broader societal impacts.

Program Accomplishments and Milestones

The Fermi National Accelerator Laboratory (Fermilab) Tevatron Collider completed its Run II at the end of FY 2011. The total integrated luminosity over the 10 year run is 12 inverse femtobarns (fb^{-1}). This large dataset, collected by the Collider Detector at Fermilab (CDF) and D-Zero detectors, was used to measure the top quark mass, make precision measurements of the W and Z bosons, exclude portions of allowed mass range for Higgs Boson, discover new particles containing b quarks, study the decay properties of B mesons, and study the properties of quantum chromodynamics.

The LHC luminosity increased by an order of magnitude in 2011 and the experiments at the LHC produced a flood of results with over 100 papers published already. These results included strong limits on the allowed mass range for the Higgs boson—with possible hints of where the Standard Model Higgs may be hiding—and limits on the

[a] http://www.acceleratorsamerica.org

masses of supersymmetric particles that are substantially better than those from the Tevatron. U.S. researchers at home and abroad have leading roles in the operations of the detectors and the LHC data analyses.

The Alpha Magnetic Spectrometer was launched into space on the Space Shuttle in May 2011 and is successfully taking data. In China, the first four Reactor Neutrino Experiment detectors are installed and taking data. Other neutrino experiments in Europe and Japan reported initial measurements of the remaining unknown neutrino mixing angle which indicate this mixing is large; these exciting preliminary results are being followed up by reactor experiments as well as the accelerator-based neutrino experiments at Fermilab. Other recent interesting but controversial neutrino results (such as "faster-than-light" neutrinos) are also being cross-checked by Fermilab experiments.

Milestone	Date
First light for the Dark Energy Camera	September 2012
Shutdown of the Fermilab accelerator complex for installation of the NOvA Accelerator Upgrades: These upgrades will raise the beam power available for NuMI beam from 320 kilowatts to 700 kilowatts	3rd Quarter, FY 2012

Explanation of Changes

In the FY 2013 request, funds are shifted from proton facility operations and advanced technology R&D to support the planned funding profile for Muon to Electron Conversion Experiment (Mu2e), to conduct R&D targeted for future intensity and cosmic frontier projects, and to maintain the level-of-effort in HEP research. No construction funds are requested for the Long Baseline Neutrino Experiment (LBNE). Capital equipment funding is requested for two new major items of equipment (MIEs): the camera for the Large Synoptic Survey Telescope (LSSTcam) and a U.S. contribution to the upgrade of the Belle detector at the Super B-Factory in Japan.

Program Planning and Management

To ensure that resources are allocated to the most scientifically promising experiments, DOE actively seeks external input using a variety of advisory bodies. The High Energy Physics Advisory Panel (HEPAP), jointly chartered by DOE and the National Science Foundation (NSF), provides advice regarding the scientific opportunities and priorities of the national high energy physics research program. HEPAP and its subpanels undertake special studies and planning exercises in response to specific charges from the funding agencies.

The HEPAP P5 report[a] (June 2008) provided important input informing HEP programmatic priorities. A subsequent HEPAP report to identify and prioritize the scientific opportunities and options that can be pursued at different funding levels to achieve an optimum program in particle astrophysics refined this guidance.

The National Academies Decadal Survey of Astronomy and Astrophysics (Astro2010) report[b] (August 2010) recommended priorities for the next decade for the U.S. program in astronomy and astrophysics under various funding scenarios. This study provides advice on the opportunities for HEP participation in astrophysics experiments and also provides guidance on scientific and technical aspects of the proposed program. HEP's budget and planning for FY 2013 are consistent with this advice obtained from the scientific community and the implementation of a coordinated interagency national program that will deliver the best science with the available resources in this scientific area.

The Astronomy and Astrophysics Advisory Committee (AAAC) reports on a continuing basis to DOE, NSF, and NASA with advice on the direction and management of the national astronomy and astrophysics research programs. The AAAC operates similarly to HEPAP, and the two advisory bodies have been charged to form joint task forces or subpanels to address research issues at the intersection of high energy physics, astrophysics, and astronomy, such as dark energy and dark matter and the study of high energy cosmic and gamma rays.

For the HEP research programs, HEP triennially convenes a Committee of Visitors (COV) to perform an independent review of HEP's solicitation, proposal, and research management processes, as well as an evaluation of the quality, performance, and relevance of the research portfolio, including an assessment of its breadth and balance. The third HEP COV review took place in fall 2010.

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[a] http://go.usa.gov/Xgf

[b] http://www.nap.edu/catalog.php?record_id=12951

HEP reviews and provides ongoing oversight of its research portfolio. All university research proposals are subject to an external peer review process to ensure high quality research and relevance to achieving the goals of the national program. Proposals for grant support are peer-reviewed by external technical experts, as they are for all Office of Science research programs, following the guidelines established by 10 CFR Part 605.

Following recommendations of the 2007 COV, HEP implemented a new review process for high energy physics research and basic technology R&D efforts at DOE laboratories. Laboratory high energy physics research and technology R&D groups are peer-reviewed triennially on a rotating basis, using the same criteria established for the university reviews. In FY 2013, HEP plans to review the Electron Accelerator Based Research and Non Accelerator Based Research subprograms. Laboratory proposals involving significant new research scope are also subject to peer-review by external experts on an ad hoc basis.

Program Goals and Funding

HEP balances the scientific priorities of the research community with the constraints of the facilities, tools, and resources available. Research facilities for high energy physics generally require significant investments over many years and the coordinated efforts of international teams of scientists and engineers to realize accelerators and detectors that push the frontiers of energy, intensity, and cosmic exploration.

HEP, with input from the scientific community, has developed a long-range plan which maintains a leadership role for the U.S. within this global context. The plan shifts focus from the operation of the facilities built in the 1990s to the design and construction of new research facilities and instruments, while maintaining a world-leading scientific program and supporting advanced technology R&D for the future. This strategic plan positions the Nation to play a role at all three frontiers of particle physics. Proposed FY 2013 investments will develop capabilities for future accelerator-based experimental research facilities.

The Energy Frontier: The Tevatron Collider at Fermilab completed operations in 2011. Its record-breaking performance in data delivery resulted in a dataset that will continue to be mined for significant discoveries during the first few years of Large Hadron Collider (LHC) operations at CERN. In FY 2013, HEP will support the needs of researchers to continue to exploit the Tevatron data. HEP's primary scientific goals over the next five years are to enable such discoveries—for example, the Higgs boson and supersymmetric particles—either from Tevatron data or LHC data now being acquired, by supporting the best researchers working in this area. No new Energy Frontier facility investments are anticipated until plans for LHC upgrades are decided.

First beam collisions at the LHC occurred in November 2009. The first run of the LHC is currently planned to end in late 2012 with a dataset comparable in size to the entire Tevatron Collider run. After a year-long consolidation and maintenance period, it is planned to resume running at its design energy (14 TeV center of mass). In FY 2013, HEP will provide support for LHC detector operations, maintenance, computing, and R&D necessary to maintain a significant U.S. role in the LHC program, including the operations of large U.S. data centers for the two major LHC experiments. CERN may delay the shutdown and extend the run into 2013 if it is warranted by the emergence of new physics as the data are analyzed.

The Intensity Frontier: The Neutrinos at the Main Injector (NuMI) beamline at Fermilab will operate in its current configuration through mid-FY 2012 for ongoing neutrino experiments and then will shut down for a year-long upgrade to enhance the beam power from approximately 400 to 700 kW for the NuMI Off-Axis Neutrino Appearance (NOvA) experiment. The NOvA project, currently under fabrication, will be in full operation in 2014 to enable key measurements of neutrino properties. In FY 2012, engineering and design funding is provided for the Long Baseline Neutrino Experiment (LBNE) and the Muon to Electron Conversion Experiment (Mu2e).

The HEP program has been developing the LBNE project, with the Homestake mine in South Dakota as a possible site for a far detector. The National Science Foundation was a potential partner in development and operations of the LBNE far detector but has chosen not to participate. Since DOE would now be responsible for the full development, operation, and maintenance of the Homestake site, the estimated costs associated with the LBNE far detector have risen significantly. The Office of Science is undertaking a thorough review of the costs and alternatives to LBNE and expects to make decisions concerning a future intensity frontier project in 2012.

During FY 2012, High Energy Physics will support activities for minimal, sustaining operations at the Homestake mine in South Dakota while completing existing experiments at Homestake. HEP is requesting continued funding for these maintenance activities in FY 2013. The Nuclear Physics program provides additional funding in FY 2012 only.

The Cosmic Frontier: HEP is coordinating its program of world class space-based and ground-based particle astrophysics experiments and observatories for exploration of the Cosmic Frontier with NASA and NSF. The effects of dark energy and dark matter were both first discovered in astronomical observations, but most of the proposed causes of these effects are due to the properties of elementary particles or fields, and this has drawn the interest of particle physicists. They have brought new instrumentation and data handling techniques from high energy physics to astronomy and particle astrophysics to support these studies of dark matter and dark energy.

In FY 2013, funding supports existing and ongoing endeavors studying cosmic rays, gamma rays, dark energy and searching for dark matter. Looking to the future, HEP has utilized HEPAP guidance and the Astro2010 report on scientific priorities to mount a U.S. program that will advance our understanding of dark matter and dark energy. HEP is collaborating with NSF on a staged program of research and technology development and experiments designed to directly detect dark matter particles using ultra-sensitive detectors located underground. HEP is also working with NSF on implementing the Large Synoptic Survey Telescope (LSST) for studies of dark energy using a new ground-based telescope facility. The FY 2013 request supports a ramp up of engineering and design efforts for the camera for LSST (LSSTcam) as well as R&D and scientific studies for dark matter experiments and other possible future initiatives.

Office of Science performance expectations (and therefore funding requests) are focused on four areas:

- *Research*: Carry out research across the three experimental frontiers of particle physics to address the most basic questions about the world around us.
- *Facility Operations*: Support optimal utilization of the HEP user facilities to deliver maximal data to the user community, while carrying out a maintenance and improvement program that will keep the facility productive well into the future.
- *Future Facilities*: Develop new facilities and instrumentation for the Intensity and Cosmic Frontiers for a scientific leadership program in the U.S. All construction projects and MIEs are within 10% of their specified cost and schedule baselines.
- *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	Facility Operations	Future Facilities	Workforce
Proton Accelerator-Based Physics	30%	55%	15%	0%
Electron Accelerator-Based Physics	50%	30%	20%	0%
Non-Accelerator Physics	75%	0%	25%	0%
Theoretical Physics	100%	0%	0%	0%
Advanced Technology R&D	100%	0%	0%	0%
Construction	0%	0%	100%	0%
Total, High Energy Physics	55%	30%	15%	0%

Explanation of Funding and Program Changes

	(Dollars in Thousands)		
	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Proton Accelerator-Based Physics	421,594	411,532	-10,062
The end of Tevatron Collider running in September 2011 and planned shutdown to install neutrino beamline upgrades in 2013 drive the changes in Proton Accelerator-Based Physics.			
Electron Accelerator-Based Physics	23,025	29,146	+6,121
The beginning of the U.S. contribution to the Belle-II detector upgrade as an MIE accounts for the funding increase for Electron Accelerator-Based Physics.			
Non-Accelerator Physics	84,062	97,425	+13,363
Engineering and design efforts ramp up for the Large Synoptic Survey Telescope camera project and R&D funding for next-generation dark matter experiments are the major drivers of the increase in this subprogram.			
Theoretical Physics	66,850	68,522	+1,672
Funding is approximately constant with Computational HEP and theory research increases slightly.			
Advanced Technology R&D	167,329	149,896	-17,433
The International Linear Collider (ILC) R&D program is completed in calendar year 2012, which is the driver for the significant decrease in this funding category.			
Construction	28,000	20,000	-8,000
Project Engineering and Design (PED) funding continues for the Muon to Electron Conversion Experiment according to the planned profile. No PED funding is requested in FY 2013 for the Long Baseline Neutrino Experiment. HEP will assess costs, scientific priorities, and capabilities in the intensity frontier.			
Total, High Energy Physics	790,860	776,521	-14,339

Proton Accelerator-Based Physics
Funding Profile by Activity

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Research	135,128	122,894	125,394
Facilities	303,727	298,700	286,138
Total, Proton Accelerator-Based Physics	438,855	421,594	411,532

Overview

The Proton Accelerator-Based Physics subprogram exploits the application of proton accelerators at two of the primary scientific frontiers of High Energy Physics:

- At the Energy Frontier, LHC experiments will be used to determine whether the Standard Model correctly predicts the mechanism that generates mass for all fundamental particles and will search for the first clear evidence of new physics beyond the Standard Model.
- At the Intensity Frontier, experiments using the beams from Fermilab and the Japanese proton accelerator facility, Japan Proton Accelerator Research Complex (J-PARC), will make precise, controlled measurements of basic neutrino properties and will provide important clues and constraints on the new world of matter and energy beyond the Standard Model.

The Energy Frontier activity supports LHC research and analysis of legacy data from the Tevatron experiments at Fermilab with the aim of determining whether the Standard Model is a correct description of the natural world. In addition, research carried out at universities and national laboratories will either find evidence of new physics beyond the Standard Model or significantly constrain current models of Supersymmetry, black hole production, extra dimensions, and other exotic phenomena. LHC hosts two large multipurpose particle detectors that are fabricated, maintained and operated by scientific collaborations of hundreds to thousands of research scientists who analyze the data and publish their results. Results from multiple experiments are often combined as appropriate to improve the statistical significance of the results.

The Intensity Frontier program in proton accelerator-based research utilizes multiple experimental approaches to understand new physics associated with fundamental questions about neutrino properties, the predominance of matter in the universe, and why there are so many kinds of “fundamental” particles. This program includes a series of neutrino experiments that measure neutrino oscillations with increasing precision and different experimental approaches (Main Injector Neutrino Oscillation Search [MINOS], Tokai to Kamioka [T2K], and NuMI Off-Axis Electron Neutrino Appearance [NovA]); neutrino interaction cross-sections in different energy ranges and various detector technologies (MiniBooNE, Main Injector Experiment v-A [MINERvA], and MicroBooNE); precision measurements of rare decay processes involving muons (the proposed g-2 and Mu2e) and kaons (K0TO) that provide opportunities to discover new phenomena. These are typically smaller experiments, with tens to a few hundred scientists collaborating, that are optimized to make a small number of key measurements. One unifying theme that connects these diverse experiments is they all require intense particle beams to search for processes that occur rarely in nature.

Explanation of Funding Changes

In FY 2013, analysis of legacy Tevatron data will continue, although at a reduced level. Most Tevatron research efforts will be re-directed to either the LHC or the Intensity Frontier. Research activities at the Energy Frontier in FY 2013 will primarily be focused on the LHC. Operation and data taking of the NOvA experiment commence in 2013. The MicroBooNE experiment completes its project funding in 2013.

	(Dollars in Thousands)		
	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Research	122,894	125,394	+2,500
Overall funding for the research program at universities and national laboratories is maintained at approximately the FY 2012 level of effort.			
Facilities	298,700	286,138	-12,562
In FY 2013, the Fermilab accelerator complex will be shut down for approximately half the year while the accelerator upgrades for the NOvA project will be completed. There will be a three month commissioning period followed by a three month run to support the neutrino program including the first data-taking with the partially completed NOvA detector.			
Total, Proton Accelerator-Based Physics	421,594	411,532	-10,062

Research

Overview

The grant-based HEP experimental research program at the Energy Frontier consists of groups at over 60 institutions performing experiments at proton accelerator facilities. Intensity Frontier research supports about 30 university-based groups. Grant-supported scientists typically constitute about 50–75% of the personnel needed to create, run, and analyze an experiment, and they usually work in collaboration with other university and laboratory groups. Grant-based research efforts are selected based on peer review. The detailed funding allocations will take into account the quality and scientific priority of the research proposed.

Proton Accelerator-Based Physics research also supports physicists from 5 national laboratories (Argonne, Berkeley Brookhaven, Fermi, and SLAC) for Energy Frontier and the Intensity Frontier. These can be large groups that also have significant responsibilities for detector operations, maintenance, and upgrades, particularly when their laboratory is hosting the experiment. HEP conducted a comparative peer review of laboratory research groups in this subprogram in 2009, and findings from this review were used to inform the funding decisions in subsequent years. HEP will review this subprogram again in 2012 and evaluate progress.

U.S. researchers will continue to play a leadership role in the physics discoveries at the LHC. Achieving this goal requires effective integration of U.S. researchers in the LHC detector calibration and data analysis efforts, and implementation and optimization of the U.S. data handling and computing capabilities needed for full participation in the LHC research program. These latter efforts are supported under the Facilities activity.

The neutrino program includes several experiments in differing stages of completion. Current neutrino experiments that are expected to complete data taking by 2012 include MINOS and MiniBooNE. The data analysis from MINOS and MiniBooNE will wind down within a few years, and research will be redirected to the next generation of neutrino oscillation experiments. Current experiments that continue operations are MINERvA at Fermilab and T2K in Japan. Experiments in the fabrication and commissioning phase are NOvA and MicroBooNE. LBNE is in the conceptual design phase, but as noted above, the Office of Science is carefully reviewing costs and alternatives before making any critical decisions. Many research groups work on analysis from one or more experiments while also pursuing R&D for future experiments.

Recent results from MINOS and T2K strongly suggest that the remaining—as yet unmeasured—neutrino mixing parameter may be large enough that NOvA will also have unique sensitivity to resolve a number of outstanding questions in the neutrino sector.

The Intensity Frontier also includes support for research on properties of muons. Two experiments are currently planned: the Muon to Electron Conversion Experiment and the measurement of the muon anomalous magnetic moment, also called muon g-2. These use precision measurements to probe new physics beyond the Standard Model.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	Research funding for Proton Accelerator-based physics was dominated by the Energy Frontier of the Tevatron and the LHC. The remaining activities were Intensity Frontier experiments in neutrino physics such as the MINOS, MINERvA, and MiniBooNE experiments at Fermilab.	135,128
2012 Enacted	Grant and laboratory energy frontier research funding are reduced in order to accommodate the expected ramp-down of Tevatron research and a redirection to Intensity Frontier research. High-priority data analysis efforts in the Tevatron Collider program will be maintained but there will be reductions in the broader Tevatron research effort, while remaining scientific staff will refocus efforts from detector operations to data analysis.	122,894

Fiscal Year	Activity	Funding ($000)
2013 Request	A further reduction in Tevatron research is planned, reflecting completion of several precision measurements and legacy searches for new physics; this is offset by continued investments in the Intensity Frontier. Within this activity, the priority efforts in FY 2013 will be in support of LHC research and growth of a strong neutrino physics program. While scientists analyze the large data samples collected in more than two years of running, the LHC will shut down early in the fiscal year to perform repairs that will allow it to operate at its design energy. U.S. university and laboratory scientists will also participate in the maintenance and preparation for high energy and high intensity running of components built in the United States. Initial NOvA data taking (with a partially completed detector) begins. Support for the accelerator-based research in the Intensity Frontier program is also a high priority.	125,394

(dollars in thousands)

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Grants Research	57,505	61,584	62,834
National Laboratory Research	74,811	61,225	62,475
University Service Accounts	2,812	85	85
Total, Research	135,128	122,894	125,394

Facilities

Overview

The Proton Accelerator-Based Physics Facilities activity supports the operation of the Fermilab accelerator complex and experiments that utilize it, as well as research and development to improve the operation of the complex. The complex currently operates two neutrino beams with different energies needed for different experiments: the Booster neutrino beam using 8 GeV protons from the Booster accelerator to make neutrinos and the Neutrinos at the Main Injector (NuMI) beam using 120 GeV protons from the Main Injector to make neutrinos. Major Items of Equipment that will utilize the Fermilab accelerator complex are also included, which currently are NOvA and MicroBooNE.

The LHC Operations program is also funded in this activity. It supports the maintenance of U.S. supplied detector systems for the Compact Muon Solenoid (CMS) and A Toroidal LHC ApparatuS (ATLAS) detectors at the LHC and the U.S. based computer infrastructure for the analysis of LHC data by U.S. physicists, including Tier 1 computing centers at Fermilab and Brookhaven National Laboratory.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	The Tevatron and the neutrino program both operated for 5,400 hours (44 weeks) in FY 2011. This was the last year of operations for the Tevatron. The LHC operations program continues. HEP prepositioned $500,000 to support minimal, sustaining operations awaiting the final FY 2012 appropriation for DOE-supported activities at the Homestake mine in South Dakota; the funding was used for this purpose after passage of the appropriation.	303,727
2012 Enacted	The accelerator complex will run for 2,650 hours (22 weeks) for the neutrino program and then shut down for the installation of the accelerator upgrade portion of the NOvA project. This will raise the beam power delivered to the NuMI neutrino production target from 400 kilowatts to 700 kilowatts. The LHC operations program is held constant. The Other Facilities category is increased to support pumping water from the Homestake mine to preserve the investments there in the Lux dark matter and Majorana demonstrator experiments, while the Office of Science determines if it can be used for its own initiatives in underground Science, including neutrino physics and dark matter searches. $9,500,000 is provided by the High Energy Physics program; an additional $4,500,000 is provided from the Nuclear Physics program. The National Science Foundation funded dewatering activities in FY 2011 and the first quarter of FY 2012.	298,700
2013 Request	The shutdown for the installation of the accelerator upgrade portion of the NOvA project continues. The complex will be restarted in the middle of the year with 12 weeks planned for commissioning and run for 2,400 hours (20 weeks) for the neutrino program. Final funding for the NOvA MIE and the MicroBooNE MIE is provided. A portion of the NOvA detector will begin operations, while the remainder is installed. Capital equipment funding in Proton Accelerator Complex Support is increased to carry out refurbishment of the Booster accelerator, which is the oldest portion of the complex dating back to the early 1970s. General plant project funding is increased for a new experimental hall to house experiments utilizing muon beams.	286,138

Fiscal Year	Activity	Funding ($000)

The State of Illinois has provided a grant to construct a new building at Fermilab that will bring together the diverse strengths of the laboratory in accelerator R&D and related technology developments, and enable closer ties with industry and other partners who benefit from broader applications of accelerator technology. HEP is supporting refurbishment of existing laboratory space using facilities infrastructure funding that will abut the new building and provide excellent work space to enable larger-scale R&D efforts.

Funding is increased for future Intensity Frontier facilities and experiments, in response to the many scientific opportunities identified by the HEP community workshop held in December 2011.

Funding for the LHC operations program is held at approximately the FY 2012 level.

Funding for de-watering and minimal operations of the Homestake mine continues ($10,000,000).

(Dollars in Thousands)

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Proton Accelerator Complex Operations	129,910	102,376	107,201
Proton Accelerator Complex Support	14,360	21,865	27,088
Proton Accelerator Facility Projects			
Current Facility Projects	68,388	70,240	40,337
Future Facility R&D	10,700	14,400	18,915
Total, Proton Accelerator Facility Projects	79,088	84,640	59,252
Large Hadron Collider Support			
LHC Accelerator Research	12,350	12,390	12,390
LHC Detector Support	58,804	60,754	61,024
LHC Upgrades	1,500	0	0
Total, Large Hadron Collider Support	72,654	73,144	73,414
Other Facilities	7,715	16,675	19,183
Total, Facilities	303,727	298,700	286,138

Electron Accelerator-Based Physics
Funding Profile by Activity

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Research	14,645	12,550	13,946
Facilities	9,809	10,475	15,200
Total, Electron Accelerator-Based Physics	24,454	23,025	29,146

Overview

The Electron Accelerator-Based Physics subprogram utilizes accelerators with high-intensity and ultra-precise beams to create and investigate matter at its most basic level. In FY 2013, HEP will support U.S. researchers' participation in the Japanese B-Factory at the National Laboratory for High Energy Physics (KEK) and a collaboration of U.S. researchers will be engaged in R&D and fabrication of components for U.S. contributions to an upgrade of the Belle detector at KEK. The Japanese B-Factory is scheduled for a major upgrade in FY 2014–2015 that will improve its luminosity by a factor of 50–100 in order to increase its sensitivity to physics beyond the Standard Model and make it complementary to the Large Hadron Collider (LHC) at CERN.

The SLAC B-Factory completed operations in 2008 and this facility is in a decommissioning and disassembly phase. This effort will increase in FY 2013 as disassembly of the accelerator complex begins.

Explanation of Funding Changes

The "steady analysis" period dedicated to completing the major discovery and analysis topics in the SLAC B-Factory data set comes to an end in FY 2012. The analysis effort will shrink by approximately 50% in FY 2013 and the effort will focus on long term data analysis and data archiving. This decrease is offset by a ramp-up in research and R&D activities associated with U.S. participation in the Japanese B-Factory program.

The decommissioning and decontamination (D&D) of the B-Factory detector will be completed in FY 2013. Components of the detector will be ready for reuse at other facilities or for disposal. The D&D of the B-Factory accelerator will begin in FY 2013 with disassembly of accelerator components and is planned for completion in FY 2017.

Funding for fabrication of the U.S.-supplied components for the upgrade of the Japanese B-Factory detector begins in FY 2013 and is scheduled to complete in FY 2014.

	(Dollars in Thousands)		
	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Research	12,550	13,946	+1,396

Funding increases for U.S. researchers beginning work on U.S. contributions to the Belle II upgrade at the Japanese KEK facility, offset by the ramp-down of the analysis of the SLAC B-Factory data set, as it begins a smaller archival analysis phase.

	(Dollars in Thousands)		
	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Facilities	10,475	15,200	+4,725
The MIE fabrication for the U.S. contribution to the Belle detector upgrade at the Japanese B-Factory begins (estimated TPC $12,650,000) and is the major driver of the increase in funding. In FY 2013, the D&D of the SLAC B-Factory detector will be complete and the disassembly of the accelerator complex starts to ramp up.			
Total, Electron Accelerator-Based Physics	23,025	29,146	+6,121

Research

Overview

The research program at the B-Factory/BaBar Facility at SLAC, which is centered on the analysis of the very large data set that has been accumulated over the nine-year operational life of the facility, will continue winding down. Physicists from approximately 20 universities, 3 national laboratories (Berkeley, Livermore, and SLAC), and 7 foreign countries have been actively involved in the data analysis. The research programs at other electron accelerator facilities complement the B-Factory/BaBar efforts and consist of a group of experimental research activities using the KEK-B electron accelerator facilities in Japan (currently supporting 5 university groups) and recently upgraded electron accelerator facilities in China (supporting 6 university groups). There are also small R&D efforts aimed at designing detectors for next-generation off-shore "Super-B factories." HEP is supporting modest participation in the future Japanese Super-B factory upgrades and research program. That effort has begun and a U.S. Belle II collaboration has formed and is being coordinated through the Pacific Northwest National Laboratory (PNNL). Funding for the U.S.-supplied detector components is included as a major item of equipment in this Request (Belle-II, estimated TPC $12,650,000).

The national laboratory research program consists of modest-sized groups participating in experiments at electron accelerator facilities with a physics program similar to the research program described above. Electron accelerator research activities concentrate on experiments at the SLAC B-Factory and the detector upgrade at the Japanese KEK-B facility. HEP conducted a comparative peer review of laboratory research groups in this subprogram in FY 2010 and funding allocations reflect the findings of that review.

A new small scale initiative, the Heavy Photon Search (HPS), is an accelerator-based search experiment that focuses on weakly-coupled, light particles that may explain anomalies seen in some earlier experiments, including connections to Dark Matter. HPS was reviewed favorably in March 2011 and will test equipment at Thomas Jefferson National Accelerator Facility (TJNAF) in the summer of 2012. The scientific collaboration includes university researchers and scientists at SLAC and TJNAF. If the test runs are successful, a full scale search may occur in FY 2014-2015 at TJNAF.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	Research funding for Electron Accelerator-based physics was dominated by data analysis for the BaBar detector. Smaller research efforts on the Japanese Belle detector and the Chinese Beijing Electron Positron Collider (BEPC) program, and R&D for future facilities, were also supported.	14,645
2012 Enacted	Funding continues at a reduced level of effort as BaBar analysis continues to ramp-down. Support is provided to complete the final analysis of physics data from Belle and BaBar. Smaller efforts devoted to operations and data analysis at the Beijing Spectrometer at BEPC will also be supported. Laboratory-based research in this activity continues at a reduced level of effort and will be focused on completing the highest-priority data analysis from BaBar. The research groups at SLAC, as well as the other laboratories, will be in transition as they ramp down activities, complete analyses, and phase into new research activities.	12,550
2013 Request	The research efforts on the BaBar data set will enter their archival analysis phase and will decrease accordingly. Those efforts are anticipated, however, to involve several dozen graduate students and are expected to produce between 20 and 30 publications. The research efforts on the Belle II detector at the Japanese KEK-B facility are expected to grow modestly.	13,946

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Grants Research	5,024	4,754	6,150
National Laboratory Research	9,551	7,738	7,738
University Service Accounts	70	58	58
Total, Research	14,645	12,550	13,946

Facilities

Overview

The SLAC B-Factory completed operations in the spring of 2008. The decommissioning and decontamination (D&D) of the B-Factory detector will be completed in FY 2013. The components of the detector will be ready for reuse at other facilities or for disposal. The D&D of the B-Factory accelerator will begin in FY 2013 and is planned for completion in FY 2017. A small but growing effort on the design and fabrication of the upgraded Belle II detector at the Japanese Super KEK-B facility will be coordinated through the Pacific Northwest National Laboratory (PNNL).

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	The D&D of the BaBar detector began ramping down and planning for the D&D of the PEP-II accelerator continued. Funding included ongoing support for maintenance and operations of computing infrastructure to complete analysis of the very large dataset.	9,809
2012 Enacted	The funding level increases modestly as R&D activities for the Belle detector upgrade ramp-up, offset by the completion of the "steady analysis phase" of the BaBar data set.	10,475
2013 Request	The D&D of the PEP-II accelerator starts to ramp up. The archiving of the BaBar data set begins. The MIE fabrication for the U.S. contribution to the Belle detector upgrade at the Japanese B-Factory begins (estimated TPC $12,650,000) and is the major driver of the increase in funding.	15,200

(Dollars in Thousands)

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Electron Accelerator Complex Operations	8,880	8,925	8,925
Electron Accelerator Complex Support	900	900	275
Electron Accelerator Facility Projects			
Current Facility Projects	0	650	6,000
Future Facility R&D	29	0	0
Total, Electron Accelerator Facility Projects	29	650	6,000
Total, Facilities	9,809	10,475	15,200

Non-Accelerator Physics
Funding Profile by Activity

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Research	70,355	69,562	70,962
Projects	19,712	14,500	26,463
Total, Non-Accelerator Physics	90,067	84,062	97,425

Overview

The Non-Accelerator Physics subprogram provides U.S. leadership in the study of topics in high energy physics that cannot be investigated with accelerators or are best studied by other means. The activities in this subprogram are complementary to accelerator-based research and play an important role in the HEP program, providing experimental data and new ideas, as well as using ever more sophisticated techniques to probe fundamental physics questions with naturally occurring particles and phenomena.

Scientists in this subprogram investigate topics central to both the Intensity and Cosmic Frontiers, such as dark matter, dark energy, neutrino properties, the highest energy cosmic rays and gamma rays, studies of inflation in the early universe and primordial antimatter. These areas of research probe well beyond the Standard Model of particle physics and offer possibilities for discovery of major new physics phenomena. This subprogram supports both university and national laboratory researchers who collaborate on conducting experiments.

Cosmic frontier experiments in this subprogram can be classified into three main categories: searches for dark matter, studies of the nature of dark energy, and measurements of cosmic and gamma rays. Small experiments to search for dark matter are being carried out using a variety of technologies in order to determine which is most effective. These experiments have started to probe the range of cross-sections and masses that have been predicted by theories of supersymmetry.

Current studies of dark energy have concentrated on using two techniques: type Ia supernovae and baryon acoustic oscillations. These are being done on existing telescopes with either new or upgraded instruments. High energy cosmic and gamma rays can be studied from the ground while lower energy particles need to be studied in space.

Intensity Frontier experiments in the non-accelerator physics subprogram are currently all related to neutrinos. These include studies of neutrino oscillations using neutrinos from nuclear reactors and searches for neutrinoless double beta decay, which are carried out in deep underground laboratories.

The Non-Accelerator Physics subprogram supports the fabrication of several major items of equipment. The Dark Energy Survey (DES) and the Reactor Neutrino Detector at Daya Bay experiment are completing fabrication in 2012. The High Altitude Water Cherenkov (HAWC) experiment, which will study gamma rays, started fabrication in FY 2012. Engineering and design efforts ramp up for the Large Synoptic Survey Telescope camera (LSSTcam) project, which will be used for dark energy measurements.

Explanation of Funding Changes

In the Non-Accelerator Physics subprogram, funding is increased primarily for the LSSTcam MIE and support for second-generation dark matter experiments.

(Dollars in Thousands)

	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Research	69,562	70,962	+1,400
Research for non-accelerator physics is maintained at approximately the FY 2012 level-of-effort.			
Projects	14,500	26,463	+11,963
Project funding is increased in FY 2013 due to the ramp up of engineering and design for the LSSTcam MIE and for technology and design studies for second-generation dark matter experiments.			
Total, Non-Accelerator Physics	84,062	97,425	+13,363

Research

Overview

The research activity supports groups at more than 35 universities and private institutions and 7 national laboratories (Argonne, Berkeley, Brookhaven, Fermi, Livermore, Los Alamos, and SLAC) that perform Cosmic Frontier experiments and at more than 20 universities and 4 national laboratories (Argonne, Berkeley, Brookhaven, and SLAC) that perform Intensity Frontier experiments at non-accelerator based facilities.

The funds provided support scientific efforts to operate the detectors, analyze the data, and develop scientific simulations and data modeling. In addition, support for the technical personnel and other expenses are provided for the maintenance and operation of experiments. Scientists supported by the research program also contribute to the R&D needed for new experiments.

The research is carried out in collaboration with other government agencies, including NSF, NASA and the Smithsonian Astrophysical Observatory. The selection of supported research efforts is based on peer review.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	At the Cosmic Frontier, operations and data analysis activities were supported on the Alpha Magnetic Spectrometer (AMS) detector, which was launched and installed on the International Space Station in May 2011. At the Intensity Frontier, support was provided for the Enriched Xenon Observatory (EXO)-200 neutrinoless double beta decay experiment, including the start of its operations; and for commissioning and initial data taking on the Reactor Neutrino Detector experiment at Daya Bay.	70,355
2012 Enacted	The research activity continues support of the ongoing program. In FY 2012, it includes the support of research on the Dark Energy Survey (DES) experiment, which begins integration and commissioning activities, and the Reactor Neutrino Detector at Daya Bay which begins its full data-taking phase.	69,562
2013 Request	Support will be provided for research on the DES experiment, which will begin its full operations phase and in support of current and promising future experiments. The Reactor Neutrino Detector at Daya Bay experiment will continue taking data with its full set of antineutrino detectors, enabling the world best measurement (or limit) on the as-yet-unmeasured neutrino mixing angle. Within this activity, the priority effort in FY 2013 will be analysis and support for currently operating experiments.	70,962

(Dollars in thousands)

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Grants Research	19,488	19,330	19,730
National Laboratory Research	50,867	50,232	51,232
Total, Research	70,355	69,562	70,962

Projects

Overview

The Projects activity funds support for technical, engineering and other professional personnel, as well as materials and supplies for small projects as well as MIE projects. Support is provided for R&D, design studies, and fabrication of the projects and experiments.

MIE projects include DES, which completes fabrication in FY 2011; the Reactor Neutrino Detector at Daya Bay, which completes fabrication in FY 2012; and HAWC, which begins fabrication in FY 2012. In FY 2013, engineering and design funding ramps up for a 3 billion pixel camera, which is DOE's responsibility in the LSST project for the study of the nature of dark energy. DOE and NSF are collaborating on the DES, HAWC, and LSSTcam projects. The activity also includes R&D and fabrication for small experiments and prototypes, as well as funding for R&D of potential future second-generation dark matter experiments, dark energy experiments, and other particle astrophysics topics. These efforts identify the most promising technical approaches in these areas. Funding decisions for these activities are based on peer review and programmatic priorities.

HEP plans to issue a solicitation in FY 2012 for R&D proposals enabling next-generation dark matter detectors. This is a very active area of R&D and technical progress where the U.S. is leading several efforts in a very competitive scientific environment. Successful proposals will be funded for one year of R&D and pre-conceptual design work in FY 2013, leading to a down-select of the most promising technologies at the end of 2013.

The selection of supported projects is based on peer review, including grant proposal reviews, laboratory comparative reviews, and advisory committee studies and reports.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	At the Cosmic Frontier, the last year of MIE support was provided for the DES project. R&D efforts were supported on future dark energy experiments, including conceptual design for LSSTcam, on dark matter technologies, and in other areas including R&D on HAWC. At the Intensity Frontier, MIE support was provided for the Reactor Neutrino Detector.	19,712
2012 Enacted	The HAWC MIE project begins fabrication and the DES project ends its fabrication phase. Preliminary design studies begin for LSSTcam. Technology R&D and activities are supported on promising second-generation dark matter experiments and promising future experiments in dark energy and other areas. The final year of MIE support is provided for the Reactor Neutrino Detector.	14,500
2013 Request	The MIE funding for HAWC fabrication is completed, with full operations starting in FY 2014. The increase in overall support is due to two priority efforts: LSSTcam ramp up of engineering and design and support for R&D leading to second-generation dark matter experimental concepts.	26,463

(dollars in thousands)

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Current Projects	7,960	7,500	11,500
Future Projects R&D	11,752	7,000	14,963
Total, Projects	19,712	14,500	26,463

Theoretical Physics
Funding Profile by Activity

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Research			
Grants Research	27,423	28,222	29,072
National Laboratory Research	25,638	23,778	24,501
Computational HEP	10,842	10,963	10,963
Other	4,147	3,887	3,986
Total, Theoretical Physics	68,050	66,850	68,522

Overview

The Theoretical Physics subprogram provides the mathematical framework for understanding and extending the knowledge of particles, forces, and the nature of space and time. This subprogram supports activities that range from detailed calculations of the predictions of the Standard Model, to the formulation and exploration of possible theories of new phenomena and the identification of the means to experimentally search for them. The subprogram also includes computational approaches to understanding the fundamental physics of the HEP program, through simulation and numerical calculation of experimental and theoretical results. This subprogram supports and advances research at all three high energy physics Frontiers.

Explanation of Funding Changes

The Theoretical Physics subprogram is maintained at approximately the FY 2012 level-of-effort. Some computational support efforts have moved into (or out of) the Computational HEP activity to Detector and Computing Operations in the Facilities activity based on a reclassification suggested by the laboratory scientific computing review held by HEP in 2011, but the net cost impact is minor.

	(Dollars in Thousands)		
	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Grants Research	28,222	29,072	+850
University grants are maintained at approximately the FY 2012 level-of-effort.			
National Laboratory Research	23,778	24,501	+723
Laboratory research efforts are maintained at approximately the FY 2012 level of effort. Detailed allocations will reflect assessments resulting from the 2011 comparative review of the national laboratory theory program.			
Computational HEP	10,963	10,963	0
Funding is unchanged.			
Other	3,887	3,986	+99
The Request increases education activities including physics conferences and workshops, and the Particle Data Group.			
Total, Theoretical Physics	66,850	68,522	+1,672

Grants Research

Overview

Grant research addresses topics across the full range of theoretical physics research. New and renewing research proposals are evaluated through a peer review process to assess scientific merit and final selection of grants to be awarded is based on these reviews as well as whether they align with programmatic priorities and overall portfolio balance. A major thrust is the search for a more complete theory that encompasses the Standard Model; in particular, a theory that can explain the underlying mechanism of electroweak symmetry breaking, the origin of particle mass, and the origin of quark and lepton flavors. A particularly interesting topic is the possibility of additional space-time dimensions that are normally hidden. This is motivated by the effort to unify Einstein's theory of gravity with quantum mechanics in a consistent way. Some of these extra dimensions and their consequences may be accessible to experimental investigation and may manifest themselves at the LHC as so-called Kaluza-Klein excitations, named after the physicists who first suggested, in the 1920s, that we might live in a 5-dimensional universe. Another topic of current research interest is the nature of dark matter and dark energy in the context of high energy physics.

University research groups play leading roles in addressing all the above research areas. This activity supports research groups at approximately 70 colleges and universities. It includes funding for private institutions, universities, and foundations that participate in high energy theoretical physics. As part of their research efforts, university groups train graduate students and postdoctoral researchers. Physicists in this theoretical research area often work in collaboration with other university and laboratory groups. Research efforts are selected based on a peer review process.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	Research funding for Theoretical Physics grants supported the ongoing program described above.	27,423
2012 Enacted	Grant research funding is increased somewhat above the FY 2011 level to accommodate current research solicitations still under review.	28,222
2013 Request	Grant research funding is increased to accommodate anticipated solicitations.	29,072

National Laboratory Research

Overview

The national laboratory theoretical research program currently consists of groups at 7 national laboratories (Argonne, Berkeley, Brookhaven, Fermi, Livermore, Los Alamos, and SLAC). The laboratory theory groups are a resource for the national research program in high energy physics, with a particular emphasis on data modeling and interpretation. This work helps to provide a clear understanding of the significance of measurements from ongoing experiments and assists in shaping and developing the laboratories' experimental high energy physics programs.

Laboratory theoretical research groups address topics across the full range of theoretical physics, including the analysis and interpretation of the new data from the LHC, accelerator and non-accelerator neutrino experiments, and dark matter detection experiments. Using the significant computing capabilities available at national laboratories, laboratory theory groups make major contributions to the U.S. and worldwide lattice quantum chromodynamics (LQCD) and computational cosmology efforts.

HEP conducted a comparative peer-review of laboratory research efforts in this subfield in 2011, findings from which have been used to inform the funding decisions in this budget request.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	Research funding for Theoretical Physics grants supported the ongoing program described above.	25,638
2012 Enacted	Laboratory research funding is decreased compared to the FY 2011 level to reflect non-recurring reductions due to temporary reassignments and retirements of some laboratory staff.	23,778
2013 Request	Funding is maintained at approximately the FY 2012 level-of-effort.	24,501

Computational HEP

Overview

Scientific computing, simulation, and computational science expertise are critical for the success of theory and experiment to fulfill the HEP mission. They are necessary at all stages of an experiment—from planning and constructing accelerators and detectors, to theoretical modeling, to supporting computationally intensive experimental research, and to large scale data and data analysis. In addition, scientific simulation and advanced computing help extend the boundaries of scientific discovery to regions not directly accessible by experiments, observations, or traditional theory.

Computational HEP supports research in two broad categories: collaborations providing crucial computational tools and techniques to specific HEP research topics, and scientific computing infrastructure supporting the broader HEP community. The Scientific Discovery through Advanced Computing (SciDAC) program supports the first category and other directed research projects support the latter. The SciDAC portfolio focuses on computational science research requiring leadership class computing to solve fundamental science questions and is mostly funded via partnerships. The latter category provides for computing R&D, frameworks, networks, data resources, and related infrastructure and expertise at the laboratories; dedicated hardware for the LQCD computing initiative; and community software that is widely used throughout HEP and sometimes in other applications (such as GEANT 4 and accelerator modeling codes).

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	Current HEP SciDAC projects were funded at the planned level and supported the LQCD computing project, the LHC NET to provide data links between LHC and U.S. experiments, and the GEANT 4 software effort.	10,842
2012 Enacted	The SciDAC projects are being re-competed jointly with the Advanced Scientific Computing Research program in FY 2012 and a partnership with NSF addresses distributed computing for LHC experiments and other scientific applications. The dedicated LHC networking link is moved to the LHC Operations category while community-wide scientific computing support at SLAC and Fermilab previously supported under Facility Detector Operations is moved into Computational HEP. The LQCD project and GEANT 4 software effort are held constant.	10,963
2013 Request	The funding profile for computing partnership projects and scientific computing infrastructure activities are held at the FY 2012 funding level.	10,963

(Dollars in Thousands)

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
SciDAC	5,130	5,735	5,735
Scientific Computing	5,712	5,228	5,228
Total, Computational HEP	10,842	10,963	10,963

Other

Overview

This activity includes funding for education and outreach activities, compilations of high energy physics data, reviews of data by the Particle Data Group (PDG) at Lawrence Berkeley National Laboratory (LBNL), conferences, studies, workshops, funding for theoretical physics research activities to be determined by peer review, and for responding to new and unexpected physics opportunities.

This category also includes funding for the QuarkNet education project. This project takes place in QuarkNet centers which are set up at universities and laboratories around the country. The purpose of each center is to engage high school physics teachers in the analysis of data from an active high energy physics experiment (such as LHC). The experience these teachers garner is taken back to their classrooms in order to expose high school students to the world of high energy physics. A peer review of the QuarkNet effort is planned for 2012.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	The QuarkNet project introduced over 500 high school physics teachers to high energy physics experimental techniques. Funding for the PDG effort included a phased computing upgrade.	4,147
2012 Enacted	The appropriation supports somewhat reduced efforts in education and outreach activities, including physics conferences and workshops. The data compilations and summaries provided by the PDG will be funded according to the planned profile. The QuarkNet project will be reviewed jointly with the National Science Foundation and future funding will be determined based on that review.	3,887
2013 Request	The PDG data compilation activity will follow the planned funding profile. Other efforts are expected to continue at approximately the FY 2012 level of effort.	3,986

Advanced Technology R&D
Funding Profile by Activity

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Accelerator Science	42,104	44,150	46,850
Accelerator Development	86,801	75,400	52,600
Other Technology R&D	25,247	27,739	29,856
SBIR/STTR	0	20,040	20,590
Total, Advanced Technology R&D	154,152	167,329	149,896

Overview

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

The long-term study of physics of beams, new acceleration methods, and the limiting physical properties of accelerating cavities and superconducting magnets is supported under Accelerator Science. The Accelerator Development activity looks to select a few promising new technologies for possible future accelerator projects and conduct directed R&D for these projects, with proof-of-principle demonstrations, prototype component development, and other milestones advancing technical readiness.

Advanced Technology R&D also develops or enhances new technologies—such as superconducting magnets, superconducting radio-frequency accelerating cavities, high gradient and high power accelerators, and detection techniques—that are appropriate for a broad range of scientific disciplines, thereby enhancing DOE's broader strategic goals of science for Innovation, Energy, and Security.

Other Technology R&D addresses the need for the ever increasing capability of instrumentation and detectors at the Energy, Intensity, and Cosmic Frontiers. New instrumentation and detectors must constantly be developed with increased capabilities while keeping the cost and time from conception to operation at a minimum. To meet these sometimes contradictory goals, instrument builders must be constantly searching for new technologies and new ways to utilize existing technologies. To meet these challenges, HEP actively supports investment in generic instrument and detector research. These activities will benefit the detectors needed to respond to new research challenges in all three frontiers.

Explanation of Funding Changes

Overall funding for this subprogram is reduced, primarily due to completion of International Linear Collider (ILC) R&D in the Accelerator Development activity.

	(Dollars in Thousands)		
	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Accelerator Science	44,150	46,850	+2,700

FACET, the electron-beam driven plasma wakefield accelerator test facility at SLAC will be in full operation, and support of research using this new facility will be a priority. Other activities are maintained at approximately the FY 2012 level-of-effort.

	(Dollars in Thousands)		
	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Accelerator Development	75,400	52,600	-22,800
The budget reflects the completion of the ILC R&D funding and the planned profile of funding of SRF Infrastructure at Fermilab. Muon collider R&D has been reorganized following the consolidation of research activities under the Muon Accelerator Program and continues somewhat below the FY 2012 funding level.			
Other Technology R&D	27,739	29,856	+2,117
Funding is increased to support the ramp up of funding for new detector R&D activities. Emphasis will shift towards the R&D needs of the Cosmic and Intensity Frontier experiments such as liquid argon detector development.			
SBIR/STTR	20,040	20,590	+550
In FY 2011, $17,716,000 and $2,126,000 were transferred to the Small Business Innovation Research (SBIR) and Small Business Technology (STTR) programs, respectively. SBIR/STTR funding is set at 2.95% of non-capital funding in FY 2012 and 3.05% in FY 2013.			
Total, Advanced Technology R&D	167,329	149,896	-17,433

Accelerator Science

Overview

This activity focuses on understanding the science underlying the technologies used in particle accelerators and storage rings, as well as the fundamental physics of charged particle beams. Long-term research goals include developing technologies that promote scientific innovations to enable breakthroughs in particle accelerator size, cost, beam intensity and control. Funding in this category includes costs for operating university and laboratory-based accelerator R&D test facilities.

The grant-based research category investigates novel acceleration concepts, including the use of plasmas and lasers to accelerate charged particles; theoretical studies in advanced beam dynamics, including the study of non-linear optics and space-charge dominated beams; development of advanced particle beam sources and instrumentation; and accelerator R&D into the fundamental issues associated with the ionization cooling of muon beams. Research efforts are selected based on a peer review process. This program supports 30 accelerator science grants with approximately 80 scientists and 45 graduate students.

The national laboratory accelerator science category explores advanced methods to accelerate charged particles with the goal of more efficient, compact, and inexpensive particle accelerators. Efforts are focused on the long-range development of new accelerating structures and techniques needed to achieve accelerating gradients in excess of 100 MeV per meter. This work is carried out primarily at the Argonne Wakefield Accelerator at ANL; the Facility for Accelerator Science and Experimental Test Beams (FACET) and the Dielectric Laser Accelerator at SLAC; and the Berkeley Lab Laser Accelerator (BELLA), and the Lasers, Optical Accelerator Systems Integrated Studies test facility at LBNL. BNL is also the home of the highly productive Accelerator Test Facility. This facility supports HEP-funded research in accelerator concepts and beam physics, with users from academia and industry, based on a proposal-driven, peer-review process.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	Supported a broad research program in advanced accelerator physics and related technologies to investigate novel acceleration concepts.	42,104
	SLAC completed the Facility for Accelerator Science and Experimental Test Beams (FACET) and started its user-assisted commissioning and the first round of experiments.	
	LBNL started to develop diagnostics and instrumentation needed for the Berkeley Lab Laser Accelerator (BELLA) facility currently under fabrication.	
2012 Enacted	Continue support for the broad research program in advanced accelerator physics and related technologies to investigate novel acceleration concepts.	44,150
	Expect more university participation in developing proposals and conducting experiments at the new BELLA and FACET facilities.	
2013 Request	Continue support for a broad research program in advanced accelerator physics and related technologies.	46,850
	Accelerator R&D involving the fundamental issues associated with muon colliders and neutrino factories is now supported under the Muon Accelerator Program within Accelerator Development.	
	Increased funding is provided to support optimal utilization of the FACET plasma wakefield accelerator facility at SLAC.	

Fiscal Year	Activity	Funding ($000)
	Grants are maintained at approximately the FY 2012 level-of-effort. Priority will be given to support university participation in developing proposals and conducting experiments at the new advanced plasma accelerator R&D facilities, BELLA and FACET.	

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Grants Research	8,269	11,007	11,307
National Laboratory Research	33,835	33,143	35,543
Total, Accelerator Science	42,104	44,150	46,850

Accelerator Development

Overview

This activity demonstrates the feasibility of concepts and technical approaches on an engineering scale. This includes R&D and prototyping to bring new concepts to a stage of engineering readiness where they can be incorporated into existing facilities, upgrade existing facilities, or applied to the design of new facilities. Carrying out development of advanced high-technology components at this level often requires significant investments in research infrastructure. Major thrusts in this activity are superconducting radio frequency (RF) infrastructure development and studies of very high intensity proton sources for potential application in neutrino physics research.

The General Accelerator Development focuses on R&D that can be widely applied to a range of accelerator facilities. The work is primarily done at 4 national laboratories (Berkeley, Brookhaven, Fermi, and SLAC). The major areas of R&D are superconducting magnet and related materials technology; high-powered RF acceleration systems; instrumentation; linear and nonlinear beam dynamics; and development of large simulation programs. The latter effort is coordinated with the SciDAC accelerator simulation project. There is also a preconceptual R&D effort to demonstrate the advanced technologies needed to realize muon-based accelerators—this is a global R&D program with major U.S. participation at Fermilab and Brookhaven National Laboratory (BNL).

Superconducting Radio Frequency (SRF) technology is applicable to a variety of future accelerator projects central to the HEP scientific strategy. The SRF program is centered at Fermilab, supporting the development of infrastructure necessary for accelerator cavity processing, assembly, and testing and for cryomodule assembly and testing. The infrastructure will be utilized to improve cavity and cryomodule performance and prototype cryomodules for future projects. Information on processing and construction will be of use to a broad spectrum of projects throughout the Office of Science.

The ILC is a proposed TeV-scale linear electron-positron collider, widely considered by the international high energy physics community to be the successor to the LHC and essential for advancing scientific progress at the Energy Frontier. Since 2008 there has been a worldwide R&D effort, which included the U.S, to develop a Technical Design Report (TDR). The TDR is expected to be finished by the end of 2012 and combined with first physics results from the LHC will form the basis for governments to make a construction decision.

The Muon Accelerator Program (MAP) provides a five-year R&D plan for muon-based accelerators, including milestones and deliverables aimed at demonstrating the advanced technologies needed to realize muon-based accelerators for future muon colliders and neutrino factories. Research activities in muon colliders and neutrino factories under the national Neutrino Factories and Muon Collider Collaboration (NFMCC) and Muon Collider Task Force (MCTF) at Fermilab were consolidated under one single program in 2011.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	Major directed R&D efforts supported the ILC R&D program; Muon Accelerator Program; high-power RF systems R&D at SLAC; a national R&D program on superconducting magnets and materials including coordinated efforts at BNL, Fermilab and LBNL; and superconducting RF development and infrastructure at Fermilab.	86,801
2012 Enacted	Funding for General Accelerator Development is maintained at an approximately constant level of effort to continue the robust technology development program as more directed R&D efforts ramp down. The SRF effort is ramping down as major infrastructure procurements at Fermilab are completed, but continues to provide funds for procurement of components and equipment support necessary to develop prototype multi-cavity cryomodules.	75,400

Fiscal Year	Activity	Funding ($000)
	The ILC R&D program continues but with a significantly reduced U.S. role in the comprehensive and coordinated international R&D program. The MAP effort increases activities in the muon ionization cooling experiment (MICE) at the Rutherford-Appleton Laboratory and the MuCool Test Area (MTA) at Fermilab.	
2013 Request	Funding for General Accelerator Development continues at the same level as FY 2012. Funding for the SRF effort plateaus as major component procurements at Fermilab are completed; this activity will continue to develop prototype multi-cavity cryomodules, and enable continued development of U.S. capabilities for testing cavities and cryomodules. The completion of the TDR in 2012 concludes the five-year ILC R&D program. No funds are provided for the ILC R&D program in FY 2013. Funding for the MAP effort is provided slightly below the FY 2012 level in support of the R&D activities at the MICE and MTA. The R&D efforts move into a commissioning and demonstration phase with the delivery of the major experimental items such as large superconducting coupling coils and 201 MHz RF cavities.	52,600

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
General Accelerator Development	27,766	27,900	27,900
Superconducting RF R&D	19,864	13,500	13,500
International Linear Collider R&D	28,289	22,000	0
Muon Accelerators	10,882	12,000	11,200
Total, Accelerator Development	86,801	75,400	52,600

Other Technology R&D

Overview

Other Technology R&D includes addressing fundamental scientific problems to foster new technologies in particle detection, measurement, and data processing; and providing support for prototyping and detector systems development to bring the technologies to the maturity where they can be incorporated into future particle physics experiments.

The Detector Research and Development community is based at 5 national laboratories (Argonne, Berkeley, Brookhaven, Fermi, and SLAC) and multiple universities. For future detectors at the Energy Frontier, groups are working on new techniques for silicon and pixel trackers where radiation tolerance, finer segmentation, better signal to noise ratios, better heat management, and reduced mass are all very important. At the Intensity Frontier, work is directed at increasing the energy and tracking measurement sensitivities using new detector media (such as liquid argon) while, at the same time, significantly reducing the cost per ton of detector. At the Cosmic Frontier, work includes ever more sensitive charge-coupled devices for telescope cameras while increasing their versatility and reducing the cost for such detectors. Some notable projects are: research in producing a photo-detector with large area coverage but compact and inexpensive readout; development of an inexpensive solvent to add to water to make it scintillate (emit light) in the presence of high energy charged particles; and research into novel data readout using open-air laser optics, eliminating the need for much of the copper wires and fiber optic cables out of the densely packed inner regions of collider detectors.

Much of the research conducted under Other Technology R&D is applicable to other areas within the Office of Science such as the NP and BES programs. This research also leads to applications in detectors for medical uses and for national security.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	Funding supported Detector R&D, enabling a broad research program in advanced detector concepts and related technologies.	25,247
2012 Enacted	Funding will continue supporting Detector R&D efforts; in addition there will be new awards for successful proposals responding to a targeted solicitation for Collider Detector Research and Development conducted late in FY 2011.	27,739
2013 Request	Funding is increased to support the ramp up of funding for new detector R&D activities. Emphasis will shift towards the R&D needs of the Cosmic and Intensity Frontier experiments such as liquid argon detector development.	29,856

(Dollars in Thousands)

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Detector Development, Grants Research	3,079	6,646	3,763
Detector Development, National Laboratory Research	22,168	21,093	26,093
Total, Other Technology R&D	25,247	27,739	29,856

Construction
Funding Profile by Activity

(Dollars in Thousands)

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Long Baseline Neutrino Experiment	0	4,000	0
Muon to Electron Conversion Experiment	0	24,000	20,000
Total, Construction	0	28,000	20,000

Overview

In FY 2012, engineering and design funding was provided for the Long Baseline Neutrino Experiment (LBNE) to complete conceptual design studies. Because of concerns about the total project and operations costs for LBNE that could be incurred by DOE, no construction funds are requested for FY 2013, and the Office of Science will thoroughly review the costs and alternatives to LBNE.

The Muon to Electron Conversion Experiment will be built at Fermilab and is an important component of the Intensity Frontier program. It will utilize a proton beam there to produce muons and then study the conversion of those muons to electrons in order to determine if charged leptons conserve flavor. In the Standard Model, lepton flavor was assumed to be conserved, but neutrino oscillations have demonstrated that it is not conserved in neutral leptons, thus calling into question comservation by the charged leptons.

Explanation of Funding Changes

The decrease of PED funding for construction projects takes into account the planned profiles. PED funding was initially appropriated in FY 2012 for LBNE and Mu2e.

(dollars in thousands)

	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Long Baseline Neutrino Experiment	4,000	0	-4,000
No PED funding is requested in FY 2013.			
Muon to Electron Conversion Experiment	24,000	20,000	-4,000
Funding is provided for continuing project engineering and design activities.			
Total, Construction	28,000	20,000	-8,000

Supporting Information

Operating Expenses, Capital Equipment and Construction Summary

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Operating Expenses	692,027	678,413	675,089
Capital Equipment	80,374	75,772	66,532
General Plant Projects	3,177	8,675	14,900
Construction	0	28,000	20,000
Total, High Energy Physics	775,578	790,860	776,521

Funding Summary

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Research	454,082	426,145	423,093
Scientific User Facilities Operations	235,933	221,610	235,818
Projects			
Major Items of Equipment	61,680	55,390	42,837
Construction[a]	16,168	51,000	35,000
Total, Projects	77,848	106,390	77,837
Other	7,715	36,715	39,773
Total, High Energy Physics	775,578	790,860	776,521

Scientific User Facilities Operations

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Fermilab Accelerator Complex	154,970	138,641	153,204
B-Factory	9,809	9,825	9,200
LHC Detector Support and Operations	71,154	73,144	73,414
Total, Scientific User Facilities Operations	235,933	221,610	235,818

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

Total Facility Hours and Users

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Proton Accelerator Complex[a]			
Achieved Operating Hours	6,585[b]	N/A	N/A
Planned Operating Hours	5,400	2,650	2,400
Optimal hours (estimated)	5,400	2,650	2,400
Percent of Optimal Hours	122%	100%	100%
Unscheduled Downtime	19%	N/A	N/A
Total Number of Users	1,400	1,400	1,400
SLAC B-Factory			
Total Number of Users	300	200	150
Total Facilities			
Achieved Operating Hours	6,585	N/A	N/A
Planned Operating hours	5,400	2,650	2,400
Optimal hours (estimated)	5,400	2,650	2,400
Percent of Optimal Hours	122%	100%	100%
Unscheduled Downtime	19%	N/A	N/A
Total Number of Users	1,700	1,600	1,550

Major Items of Equipment (MIE)

(dollars in thousands)

	Prior Years	FY 2011 Current	FY 2012 Enacted	FY 2013 Request	Outyears	Total	Completion
Proton Accelerator-Based Physics							
NOνA							
TEC	99,528	44,220	41,240	19,480	0	204,468	1Q FY 2015
OPC	71,532	2,000	0	0	0	73,532	
TPC	171,060	46,220	41,240	19,480	0	278,000	

[a] Only NuMI runs FY 2012 and beyond.

[b] Additional operating hours were added during the year to maximize the amount of data taken at the Tevatron.

(dollars in thousands)

	Prior Years	FY 2011 Current	FY 2012 Enacted	FY 2013 Request	Outyears	Total	Completion
Accelerator Project for the Upgrade of the LHC (APUL)							
TEC	2,000	1,500	0	0	0	3,500	2Q FY 2014
OPC	8,016	0	0	0	0	8,016	
TPC	10,016[a]	1,500	0	0	0	11,516	
MicroBooNE[b]							
TEC	0	0	6,000	5,857	0	11,857	3Q FY 2015
OPC	2,043	6,000	0	0	0	8,043	
TPC	2,043	6,000	6,000	5,857	0	19,900	
Electron Accelerator-Based Physics							
Belle-II[c]							
TEC	0	0	0	6,000	6,000	12,000	3Q FY 2015
OPC	0	0	650	0	0	650	
TPC	0	0	650	6,000	6,000	12,650	
Non-Accelerator Physics							
Reactor Neutrino Detector at Daya Bay							
TEC	30,460	1,740	500	0	0	32,700	3Q FY 2013
OPC	2,480	320	0	0	0	2,800	
TPC	32,940	2,060	500	0	0	35,500	
Dark Energy Survey (DES)							
TEC	19,250	4,000	0	0	0	23,250	4Q FY 2012
OPC	11,900	0	0	0	0	11,900	
TPC	31,150	4,000	0	0	0	35,150	

[a] In FY 2011, $1,484,000 was withdrawn from prior year obligations to account for the reduced Total Project Cost identified in the baseline.
[b] The Mission Need (CD-0) was approved September 2009 and subsequent CD-1 was approved June 2010. CD-2/3a was approved September 27, 2011 with a TPC of $19,900,000.
[c] This project is not yet baselined. The Mission Need Statement was approved July 28, 2011 and the CD-0 was approved August 29, 2011.

	Prior Years	FY 2011 Current	FY 2012 Enacted	FY 2013 Request	Outyears	Total	Completion
	(dollars in thousands)						
HAWC[a]							
TEC	0	0	1,500	1,500	0	3,000	4Q FY 2014
OPC	0	0	0	0	0	0	
TPC	0	0	1,500	1,500	0	3,000	
Large Synoptic Survey Telescope (LSSTcam) Camera[b]							
TEC	0	0	0	7,000	142,600	149,600	4Q FY 2020
OPC	0	1,900	5,500	3,000	0	10,400	
TPC	0	1,900	5,500	10,000	142,600	160,000	
Total MIEs							
TEC		51,460	49,240	39,837			
OPC		10,220	6,150	3,000			
TPC		61,680	55,390	42,837			

[a] This project is not yet baselined. The TPC as well as the OPC/TEC split may change. This project falls below the $10,000,000 TPC threshold that requires a CD-0.

[b] This project is not yet baselined and the OPC/TEC split is not yet determined. This project received CD-0 on June 20, 2011.

Proton Accelerator-Based Physics MIEs:

The *NuMI Off-axis Neutrino Appearance (NOνA) Project* will use the NuMI beam from Fermilab to directly observe and measure the transformation of muon neutrinos into electron neutrinos over a distance of 700 km. The project also includes improvements to the proton source to increase the intensity of the NuMI beam. The occurrence of these particular neutrino flavor changes is expected to be much rarer than the phenomenon under study with MINOS. The baseline was approved in September 2008 with a TPC of $278,000,000. A total of $55,000,000 was provided under the Recovery Act to advance the project. Funding planned for the outyears was reduced to maintain the TPC.

Accelerator Project for the Upgrade of the LHC (APUL) is a project to design and construct selected magnets for the LHC. CD-2/3 was approved July 2011. Brookhaven National Laboratory is expected to fabricate components and deliver them to CERN for installation in the LHC.

MicroBooNE was originally planned to start in FY 2011, but was deferred after the FY 2011 appropriation did not support new project starts. Fabrication now begins in FY 2012. This project will build a several hundred ton liquid-argon neutrino detector to be used in the Booster neutrino beam at Fermilab for the measurement of low energy neutrino cross-sections. These cross sections will be measured at lower neutrino energy than MINERνA and will be important for future neutrino oscillation experiments such as T2K. This experiment will also be an important demonstration of efficacy of large-scale liquid argon time projection chambers as neutrino detectors.

Electron Accelerator-Based Physics MIEs:

The *Belle-II* project is a new MIE planned to begin fabrication in FY 2013. The project will fabricate detector subsystems for the upgraded Belle detector located at the Japanese B-Factory, which is currently being upgraded to deliver higher luminosity. Mission Need (CD-0) was approved in August 2011 with a TPC range of $12,000,000–$14,000,000.

Non-Accelerator Physics MIEs:

Reactor Neutrino Detector, located in Daya Bay, China, is being fabricated in partnership with research institutes in China. This experiment will use anti-neutrinos produced by commercial power reactors to precisely measure a fundamental parameter to help resolve ambiguities in neutrino properties and help set future directions of neutrino research. The TPC is $35,500,000 with a planned completion date of April 2013. CD-4A, Start of Initial Operations, was approved in December 2010. Data-taking with the full set of detectors starts in FY 2012.

The *Dark Energy Survey (DES)* project will provide the next step beyond the discovery of dark energy by making more detailed studies using several different observational methods. DOE is supporting the fabrication of a new camera to be installed and operated on the existing Blanco four-meter telescope at the Cerro Tololo Inter-American Observatory (CTIO) in Chile. This project is a partnership between DOE and the NSF, which operates the telescope, along with international participation. MIE funding ended in FY 2011 (TPC $35,150,000) and the experiment will start taking scientific data at the beginning of FY 2013.

The *High Altitude Water Cherenkov (HAWC)* detector is a new experiment in Mexico that will survey the sky for sources of TeV gamma-rays in the 10–100 TeV range. It was identified in the HEPAP PASAG report as a scientific opportunity that should be pursued even in the case of constrained HEP budgets. HAWC's wide field of view and continuous duty cycle will provide unique capabilities that are complementary to other gamma-ray experiments. The project is done in collaboration with NSF and Mexican research institutes. MIE funding for the fabrication starts in FY 2012. The estimated total DOE cost is $2,500,000–$3,500,000 and the estimated completion date is in FY 2014.

The *Large Synoptic Survey Telescope Camera (LSSTcam*) is a digital camera for a next-generation, wide-field, ground-based optical and near-infrared observatory, located in Chile, and is designed to provide deep images of half the sky every few nights. It will open a new window on the variable universe and address a broad range of astronomical topics with an emphasis on enabling precision studies of the nature of dark energy. LSST was identified by the National Research Council's (NRC) Astro2010 decadal survey panel as its highest priority ground-based astrophysics initiative. The project is done as a collaboration with NSF, in addition to private and foreign contributions. The DOE MIE will provide the camera for the facility. Mission Need (CD-0) for the LSSTcam project was approved in June 2011, with the estimated total DOE cost range of $120,000,000–$160,000,000 and estimated completion date of FY 2020.

Construction Projects

(dollars in thousands)

	Prior Years	FY 2011 Current	FY 2012 Enacted	FY 2013 Request	Outyears	Total	Completion
Long Baseline Neutrino Experiment (PED)							
TEC	0	0	4,000	0	TBD	TBD	TBD
OPC	26,666	7,768	17,000	10,000	TBD	TBD	
TPC	26,666	7,768	21,000	10,000	TBD	TBD	
Muon to Electron Conversion Experiment (PED)							
TEC	0	0	24,000	20,000	0	44,000	4Q FY 2018[a]
OPC	4,777	8,400	6,000	5,000	0	24,177	
TPC	4,777	8,400	30,000	25,000	0	68,177[b]	
Total, Construction							
TEC		0	28,000	20,000			
OPC		16,168	23,000	15,000			
TPC		16,168	51,000	35,000			

Scientific Employment

	FY 2011 Actual	FY 2012 Estimate	FY 2013 Estimate
# University Grants	192	195	195
# Laboratory Groups	45	45	45
# Permanent Ph.D.'s (FTEs)	1150	1170	1170
# Postdoctoral Associates (FTEs)	480	490	490
# Graduate Students (FTEs)	560	610	610
# Ph.D.'s awarded	120	105	110

[a] Estimated completion date for PED and construction.

[b] This project has not received CD-2 approval. Only PED and OPC excluding D&D are shown.

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

1. Significant Changes

The most recent DOE O 413.3B approved Critical Decision (CD) is CD-0 was approved on November 24, 2009 with a preliminary cost range of $145,000,000–$205,000,000 and CD-4 of FY 2018.

A Federal Project Director has been assigned to this project.

This PDS does not include a new start for the budget year.

This PDS is an update of the FY 2012 PDS.

When costs for the conceptual design were re-estimated in FY 2011 in anticipation of CD-1, the accelerator portion of the project was shown to be significantly more expensive than estimated at CD-0. A task force of accelerator experts was brought in by the contractor to review the design. Multiple cost savings were identified and new designs are being developed. This will extend the design period and increase the design costs, but the cost range at CD-1 is expected to be within 10% of the CD-0 cost range.

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

(fiscal quarter or date)

	CD-0	CD-1	PED Complete	CD-2	CD-3	CD-4	D&D Start	D&D Complete
FY 2011	11/24/2009	4Q FY 2010	4Q FY 2012	TBD	TBD	TBD	TBD	TBD
FY 2012	11/24/2009	4Q FY 2011	4Q FY 2013	TBD	TBD	TBD	TBD	TBD
FY 2013	11/24/2009	4Q FY 2012	4Q FY 2014	4Q FY 2013[a]	4Q FY 2014[a]	4Q FY 2018[a]	N/A	N/A

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

3. Baseline and Validation Status

(dollars in thousands)

	TEC, PED	TEC, Construction	TEC, Total	OPC Except D&D	OPC, D&D	OPC, Total	TPC
FY 2011	35,000	TBD	TBD	10,000	TBD	TBD	TBD
FY 2012	36,500	TBD	TBD	18,777	TBD	TBD	TBD
FY 2013	44,000	N/A	N/A	24,177	0	24,177	68,177[b]

[a] Schedule estimates are preliminary since this project has not received CD-2 approval.
[b] This project has not received CD-2 approval. Only PED and OPC excluding D&D are shown.

4. Project Description, Scope, and Justification

Mission Need

The conversion of a muon to an electron in the field of a nucleus provides a unique window on the structure of potential new physics discoveries and allows access to new physics at very high mass scales. The Particle Physics Project Prioritization Panel (P5) identified this opportunity as a top priority for the Intensity Frontier of particle physics. This project provides accelerator beam and experimental apparatus to identify unambiguously events of neutrinoless muon-to-electron conversion.

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

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

Key Performance Parameters

Key Parameters	Performance
Stopped-muon production system capable of delivering at least 10^{11} stopped muons per second to the experimental detector system	Installed and ready for commissioning
Experimental detector spectrometer system consisting of tracking and calorimetric detectors	Installed, tracking cosmic rays and ready for commissioning with stopped muons
Conventional facilities consisting of beam-line tunnel, detector hall below grade, surface building and cryogenics building	Over 30,000 square feet

The Key Performance Parameters will be updated at a subsequent CD approval. 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	24,000	24,000	18,000
FY 2013	20,000	20,000	17,200
FY 2014	0	0	8,800
Total, PED	44,000	44,000	44,000

(dollars in thousands)

	Appropriations	Obligations	Costs
Other Project Costs (OPC)			
OPC except D&D			
FY 2010	4,777	4,777	3,769
FY 2011	8,400	8,400	8,940
FY 2012	6,000	6,000	6,000
FY 2013	5,000	5,000	5,468
Total, OPC	24,177	24,177	24,177
Total Project Cost (TPC)			
FY 2010	4,777	4,777	3,769
FY 2011	8,400	8,400	8,940
FY 2012	30,000	30,000	24,000
FY 2013	25,000	25,000	22,668
FY 2014	0	0	8,800
Total, TPC	68,177[a]	68,177[a]	68,177[a]

6. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design (PED)			
Design	31,000	29,500	N/A
Contingency	13,000	7,000	N/A
Total, PED	44,000	36,500	N/A
Contingency, TEC	13,000	7,000	N/A

[a] This project has not yet received CD-2 approval. Only PED and OPC excluding D&D are shown.

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Other Project Cost (OPC)			
OPC except D&D			
R&D	150	150	N/A
Conceptual Planning	7,750	7,350	N/A
Conceptual Design	12,000	8,000	N/A
Contingency	4,277	3,277	N/A
Total, OPC	24,177	18,777	N/A
Contingency, OPC	4,277	3,277	N/A
Total, TPC	68,177	55,277	N/A
Total, Contingency	17,277	10,277	N/A

7. Schedule of Appropriation Requests

(dollars in thousands)

Request		Prior Years	FY 2011	FY 2012	FY 2013	Total
FY 2011	TEC	0	5,000	30,000	TBD	35,000
	OPC	5,000	5,000	0	TBD	10,000
	TPC	5,000	10,000	30,000	TBD	45,000
FY 2012	TEC	0	0	24,000	12,500	36,500
	OPC	4,777	8,000	6,000	0	18,777
	TPC	4,777	8,000	30,000	12,500	55,277
FY 2013[a]	TEC	0	0	24,000	20,000	44,000
	OPC	4,777	8,400	6,000	5,000	24,177
	TPC	4,777	8,400	30,000	25,000	68,177

8. Related Operations and Maintenance Funding Requirements

Not applicable for PED.

9. Required D&D Information

Not applicable for PED.

[a] This project has not received CD-2 approval. Only PED and OPC excluding D&D are shown.

10. Acquisition Approach

The conceptual design is being performed by Fermilab, and it will inform the acquisition approach that will be documented in the Acquisition Strategy required for CD-1. It is already known that beamlines, detectors, and an experimental hall will be needed, and that the specialized expertise in those areas will limit the range of acquisition options.

Nuclear Physics
Funding Profile by Subprogram and Activity

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Medium Energy Nuclear Physics			
Research	37,922	37,296	35,374
Operations	82,563	77,372	80,651
SBIR/STTR and Other	1,648[a]	17,909	19,235
Total, Medium Energy Nuclear Physics	122,133	132,577	135,260
Heavy Ion Nuclear Physics			
Research	40,203	39,977	38,630
Operations	161,391	160,617	158,571
Total, Heavy Ion Nuclear Physics	201,594	200,594	197,201
Low Energy Nuclear Physics			
Research	57,310	52,194	48,946
Operations	38,114	31,533	27,072
Facility for Rare Isotope Beams	10,000	22,000	22,000
Total, Low Energy Nuclear Physics	105,424	105,727	98,018
Nuclear Theory			
Theory Research	34,776	32,047	30,246
Nuclear Data Activities	8,159	7,360	6,933
Total, Nuclear Theory	42,935	39,407	37,179
Isotope Development and Production for Research and Applications			
Research	4,060	4,827	4,453
Operations	15,610	14,255	14,255
Total, Isotopes	19,670	19,082	18,708
Subtotal, Nuclear Physics	491,756	497,387	486,366
Construction			
06-SC-01, 12 GeV CEBAF Upgrade, TJNAF	35,928	50,000	40,572
Total, Nuclear Physics	527,684[a]	547,387[b]	526,938

[a] Total is reduced by $12,430,000: $11,098,000 of which was transferred to the Small Business Innovation and Research (SBIR) program and $1,332,000 of which was transferred to the Small Business Technology Transfer (STTR) program.
[b] The FY 2012 appropriation is reduced by $2,613,000 for the Nuclear Physics share of the DOE-wide $73,300,000 rescission for contractor pay freeze savings. The FY 2013 budget request reflects the FY 2013 impact of the contractor pay freeze.

Public Law Authorizations

Public Law 95-91, "Department of Energy Organization Act", 1977
Public Law 101-101, "1989 Energy and Water Development Appropriations Act," establishing the Isotope Production and Distribution Program Fund)
Public Law 103-316, "1995 Energy and Water Development Appropriations Act," amending the Isotope Production and Distribution Program Fund to provide flexibility in pricing without regard to full-cost recovery
Public Law 109-58, "Energy Policy Act of 2005"
Public Law 110-69, "America COMPETES Act of 2007"
Public Law 111-358, "America COMPETES Act of 2010"

Program Overview and Benefits

The mission of the Nuclear Physics (NP) program is to discover, explore, and understand all forms of nuclear matter. The fundamental particles that compose nuclear matter—quarks and gluons—are relatively well understood, but exactly how they fit together and interact to create different types of matter in the universe is still largely unknown. It is one of the enduring mysteries of the universe: What, really, is matter? What are the units that matter is made of, and how do they fit together to give matter the properties we observe?

The quest to understand matter takes place through theory and experiment, with both being necessary to develop a full understanding of the properties and behavior of matter. In the theoretical approach, scientists have developed a precise mathematical description of how the quarks and gluons in nuclear matter interact, referred to as Quantum Chromodynamics (QCD). However, to solve the equations of QCD is a formidable task; approximate solutions are being developed and improved with the help of today's most advanced computer systems. On the experimental side, scientists accumulate a large amount of diverse experimental data about the behavior of quarks and gluons as well as protons, neutrons, and nuclei in a variety of settings. Most of the experiments today require large accelerator facilities spanning acres. These particle accelerators slam bits of matter into each other, and scientists observe the results. The careful integration and comparison of experimental measurements with theoretical calculations provides both insight into the behavior of matter and the information needed to test the validity of theoretical models. Nuclear physics seeks to understand matter in all of its manifestations—not just the familiar forms of matter we see around us, but also such exotic forms as the matter that existed in the first moments after the creation of the universe and the matter that exists today inside neutron stars—and to understand why matter takes on the particular forms that it does.

Nuclear physics has come to focus on three broad, yet tightly interrelated, areas of inquiry. Quantum Chromodynamics seeks to develop a complete understanding of how quarks and gluons assemble themselves into protons and neutrons and how the resulting quark structure of protons and neutrons is modified in the interior of light and heavy nuclei. Nuclei and Nuclear Astrophysics seeks to understand how protons and neutrons combine to form atomic nuclei and how these nuclei have arisen during the 13.7 billion years since the birth of the cosmos. Fundamental Symmetries and Neutrinos seeks to develop a better understanding of the fundamental properties of the neutron and of the neutrino—the nearly undetectable fundamental particle produced by the weak interaction that was first indirectly detected in nuclear beta decay.

At the heart of the NP program are groups of highly trained scientists who conceive, plan, execute, and interpret the numerous experiments carried out at various nuclear physics facilities. NP supports scientists at both universities and national laboratories and is involved in a variety of international collaborations. The program provides more than 90 percent of the nuclear science research funding in the U.S. Approximately 80 Ph.D. degrees are granted annually to students for research supported by the program. Research at nine national laboratories is guided by the DOE mission and priorities and underpins strategic core competencies needed to achieve the goals of the NP program. The national laboratory scientists work and collaborate with academic scientists, other national laboratory experimental researchers, and those carrying out theoretical investigations. The national laboratory scientists collect and analyze data as well as support and maintain the detectors and facilities used in these experiments. The national laboratories also provide state-of-the-art resources for detector and accelerator R&D for future upgrades and new facilities.

NP supports facilities that complement one another and provide a variety of approaches to producing and collecting data about matter at the level of the nucleus, as well as the sub-nuclear level. The necessary facilities and equipment are large and complex, and they account for a significant portion of the program's budget—approximately 50 percent. NP currently supports three national user facilities, each with capabilities found nowhere else in the world: the Relativistic Heavy Ion Collider (RHIC) at BNL; the Continuous Electron Beam Accelerator Facility (CEBAF) at TJNAF; and the Argonne Tandem Linac Accelerator System (ATLAS) at ANL. These major scientific facilities provide research beams for a user community of approximately 3,000 scientists from all over the world. Approximately 35 percent of the users are from institutions outside of the U.S.; these institutions provide very significant benefits to the U.S. program through contributed capital, human capital, experimental equipment, and intellectual exchange. A number of other SC programs, DOE Offices (National Nuclear Security Administration and Nuclear Energy), Federal Agencies (NSF, NASA, and Department of Defense), and industries use the NP user facilities to carry out their own research programs.

The development and construction of NP facilities, advanced instrumentation, and the development of accelerator technology and computational techniques are essential for workforce development and are helping to transition the character of the U.S. workforce by creating technologies which will require high tech jobs. A recent example is superconducting radio frequency (SRF) particle acceleration, which has advanced the technology for accelerator driven sub-critical (ADS) reactors, a potential innovation for nuclear power generation and waste transmutation. Particle beams from accelerators are used in an increasingly broad range of applications including materials research, cancer therapy, food safety, bio-threat mitigation, waste treatment, and commercial fabrication. Another example is using Accelerator Mass Spectroscopy (AMS) technology to understand how to design fuel for future nuclear reactors that burns more completely, is proliferation resistant, and has reduced long-lived waste products. Enhancements in isotope production and processing techniques are leading to innovative new uses for isotopes, including neutron detectors to combat terrorism, explosives detection, oil exploration, industrial radiography, heart and lung imaging, cancer therapy, personnel protection and climate change research. These are just several examples of how stretching beyond the limits of present day science and technology to realize the groundbreaking advances made possible by strategic investments in the basic nuclear science research program helps drive innovation in areas important for a secure energy future, and for the national and economic security of the United States.

Basic and Applied R&D Coordination

The Nuclear Physics program supports an annual competitive program of targeted initiatives in Applications of Nuclear Science and Technology, the primary goal of which is to pursue forefront nuclear science research and development important to the NP mission, but which is also inherently relevant to applications. One of the goals of this initiative is to help bridge the gap between basic research and applied science. Projects include nuclear physics research relevant to the development of advanced fuel cycles for next generation nuclear power reactors; advanced, cost-effective accelerator technology and particle detection techniques for medical diagnostics and treatment; and research in developing neutron, gamma, and particle beam sources with applications in cargo screening and nuclear forensics. These initiatives are peer reviewed with participation from the applied sciences community. The integration of the underpinning nuclear science advances that have resulted from innovative basic research with the applied sciences optimizes cross fertilization, cost effectiveness, performance, and technology transfer.

The Isotope Development and Production for Research and Applications subprogram produces commercial and research isotopes that are important for basic research and applications. NP has taken significant steps in aligning the industrial and research stakeholders of the isotope program with each other and with the nuclear science research community. To ascertain current and future demands of the research community, NP continues to develop working groups with the National Nuclear Security Administration and other federal agencies, foster interactions between researchers and Isotope Program staff, obtain data from site visits, attend scientific community exhibitions and conferences, and develop strategic plans and priorities with community input. Examples include: conducting a Federal workshop to identify isotope demand and supply across a broad range of Federal agencies in support of research and applications within their areas of responsibility; playing a lead role in an interagency working group for prioritizing requested allocations of helium-3 and seeking alternative supplies; leading the joint DOE/National Institutes of

Health (NIH) federal working group to develop a strategic plan and priorities for medical isotope production; participating in the OSTP Interagency and the Organization for Economic Cooperation and Development (OECD) international working group to address the supply of molybedenum-99; and working with industry to ensure availability of isotopes of strategic and economic importance to the Nation. NP also funds isotope production development at universities to increase the Department's ability to meet researchers' requests by improving product availability and reliability. The Isotope Development and Production for Research and Applications subprogram supports research for the development of alternative production and separation techniques of stable and radioactive isotopes, and the production of research isotopes identified by National Academy reports and the Nuclear Science Advisory Committee (NSAC) as needed for high priority research opportunities across a broad range of scientific disciplines.

Program Accomplishments and Milestones

The nuclear neutron skin. Scientists have obtained first results indicating that, rather than being uniformly interspersed with protons, neutrons form a "neutron skin" in the outer radius of the heavy lead nucleus, Pb-208. This result is central to understanding the structure of heavy nuclei, and for determining the theoretical equations that describe the life cycles of neutron stars. The experiment used high intensity polarized electron beams available at the Thomas Jefferson National Accelerator Facility to determine, in a model independent way, that the neutrons occupy a larger volume than the protons in this heavy nucleus, hence, the neutron skin.

RHIC sheds light on processes that occurred in early universe. New theoretical advances and experimental analyses of nucleus-nucleus collisions at RHIC have shown scientists how to remove the effects of "ordinary" fluctuations from the observed expansion in the fire ball of subatomic particles resulting from the collisions in order to precisely determine fundamental properties of the newly created hot, dense matter. The technique relies on RHIC's ability to accelerate and collide nuclei of different species. New experimental results also indicate that the RHIC energy range spans the region where the transition takes place from hot nuclear matter to the quark-gluon plasma, providing RHIC a unique ability to study matter above and below the transition in order to understand its nature, shedding new light into the processes that formed our universe. The announcement by RHIC in 2011 of the first observation of anti-helium nuclei was recently recognized as one of the top twenty scientific achievements of 2011 by Discover Magazine.

Nuclear physicists study element production in core-collapse super novae. Understanding how nuclei that contain significantly more neutrons than protons are produced and decay in stellar processes is a nuclear physics "grand challenge" since little is known even though such processes create approximately half of the neutron-rich atomic nuclei heavier than iron. It also plays a central role in the late stage evolution of core-collapse super novae. Scientists at the Holifield Radioactive Ion Beam Facility (HRIBF) have studied the exotic zinc and gallium isotopes that are created by nature in such cataclysmic environments, and measured their lifetimes and other decay properties. Theoretical calculations incorporating these results show an appreciable redistribution of isotopic abundances for nuclei created in these extreme environments, yielding new insights on the synthesis and origin of the neutron-rich atomic elements. The capability to study such nuclei will be dramatically increased by the recently commissioned Californium Rare Isotope Breeder Upgrade (CARIBU) at Argonne National Laboratory (ANL), and the future Facility for Rare isotope Beams (FRIB) at Michigan State University (MSU).

Particle "jets" at the Large Hadron Collider. At the Large Hadron Collider (LHC), U.S. scientists have analyzed data from the world's highest energy heavy collisions using lead ion beams. They have observed sprays of very energetic particles called "jets" emanating from the collision. Studies at RHIC and the LHC of how these jets lose energy on their way out of the hot dense matter formed is important for understanding the nature and evolution of the matter in the universe in the first few moments after its creation. U.S. scientists and engineers have recently completed the fabrication of the ALICE (A Large Ion Collider Experiment) Electromagnetic Calorimeter (EMCal) project ahead of schedule and under budget. The EMCal significantly enhances the capabilities of the ALICE experiment by enabling further study of yields and correlations of the "jets."

Producing isotopes for cancer treatment. Isotope research has led scientists to promising strategies for producing isotopes which decay by alpha particle emission for use in cancer treatment. An example is research on accelerator-based production of actinium-225 being conducted by Isotope Program scientists. Actinium-225 is an alpha-emitting isotope identified as a high priority by the National Institutes of Health, which shows potential in the treatment of cancers such as leukemias and lymphomas.

Milestone[a]	**Date**
Obtain Critical Decision-2/3A for the Facility for Rare Isotope Beams to establish the schedule and cost baselines of this next generation facility for nuclear structure and nuclear astrophysics that is being constructed at MSU.	4th Qtr, FY 2012
Conduct a broad review of national laboratory research efforts in Heavy Ion Physics to ensure productivity and assess the performance of individual groups, which includes efforts at the Relativistic Heavy Ion Collider and experiments at the LHC at CERN.	4th Qtr, FY 2012

Explanation of Changes

The FY 2013 budget request is focused on optimizing, within the resources available, the scientific productivity of the program by ensuring a proper balance of investments in research, facility operations, new tools, and capabilities. It continues support for the two highest priorities in the 2007 Long Range Plan for Nuclear Science: an energy upgrade of the Thomas Jefferson National Accelerator Facility (TJNAF) Continuous Electron Beam Accelerator Facility (CEBAF) and the Facility for Rare Isotope Beams (FRIB). The FY 2013 budget is a decrease of $20,449,000 relative to the enacted FY 2012 appropriation, which includes a $6,928,000 decrease for the 12 GeV CEBAF Upgrade project (TEC and OPC). The NP national user facilities are operated for an estimated 5,360 hours of beam time for research, 38% of optimal utilization for the operating facilities, and a decrease of about 6,800 hours compared with the beam hours planned for FY 2012. The reduction in hours is a result of reduced RHIC and ATLAS operations, and a planned shutdown period at CEBAF associated with the construction of the 12 GeV CEBAF Upgrade. Funding for research across the program is reduced 5.8% relative to FY 2012.

Program Planning and Management

To ensure that funding is allocated as effectively as possible, NP has developed a rigorous and comprehensive process for strategic planning and priority setting that relies heavily on input from groups of outside experts. All activities within the subprograms are peer reviewed and performance is assessed on a regular basis. Priority is given to those research activities which support the most compelling scientific opportunities. NP has also instituted a number of peer review and oversight measures designed to assess productivity and maintain effective communication and coordination among participants in NP activities. On an as-needed basis, the program has taken the initiative to establish interagency working groups to tackle issues of common interest and to enhance communication. NP takes all of this input into account in its budget requests, making decisions to maximize scientific impact, productivity, quality, and cost-effectiveness within available resources.

NP works closely with the National Science Foundation (NSF) to jointly charter the Nuclear Science Advisory Committee (NSAC) for advice regarding compelling opportunities and productivity of the national nuclear science program. NP develops its strategic plan for the field with input from the scientific community via long range plans produced by NSAC every five to six years. These plans provide retrospective assessments of major accomplishments, assess and identify scientific opportunities, and set priorities for the next decade. The most recent long range plan for nuclear science, *The Frontiers of Nuclear Science*[b] (2007) addresses the compelling scientific thrusts in three frontiers: Quantum Chromodynamics, Nuclei and Nuclear Astrophysics, and Fundamental Symmetries and Neutrinos. In addition, NSAC completed a strategic plan in 2009 for the Isotope Development and Production for Research and Applications subprogram, *Isotopes for the Nation's Future—A Long Range Plan*[c]. As resource availability, scientific needs, and global capabilities evolve, the Nuclear Physics program needs to review its strategic plans. In FY 2012, NP will seek guidance from NSAC

[a] Subject to results of guidance sought from NSAC regarding opportunities and priorities for the Nuclear Physics program and the implementation of its strategic plan

[b] http://science.energy.gov/np/nsac

[c] http:/science.energy.gov/np/nsac/reports

regarding opportunities and priorities for the Nuclear Physics program and the implementation of its strategic plan.

NSAC provides NP with additional guidance in the form of reviews of subfields, special interest topics, and assessment of the management of the NP program itself. In February 2011, NSAC received two charges: to review and evaluate the current and proposed research program, scientific capabilities, and opportunities for fundamental nuclear physics with neutrons and make recommendations of priorities consistent with projected resources; and to provide a report to the Office of Science describing current policies and practices for disseminating research results in the fields relevant to the Nuclear Physics program. The reports from both charges were transmitted to DOE and NSF in FY 2011. NP strategic plans are also influenced by National Academy reports and Office of Science and Technology Policy (OSTP) and National Security Council (NSC) Interagency Working Group (IWG) efforts, the latter two under the auspices of the White House Executive Office of the President. The National Academies study *Advancing Nuclear Medicine through Innovation*[a] motivated NP to establish a federal working group with the National Institutes of Health (NIH), along with the Office of Science (SC) Biological and Environmental Research program, to better coordinate radioisotope production and to address other issues important to nuclear medicine. The National Academies embarked on a new decadal study of nuclear science in 2009. In order to optimize interagency activities, NP is currently involved in three OSTP or NSC IWG's: Forensic Science, Molybdenum-99 Production, and Helium-3 Shortage.

NP peer reviews all of its activities. Biennial science and technology reviews of the national user facilities and isotope production facilities with panels of international peers assess operations, performance, and scientific productivity. These results influence budget decisions and NP's assessment of laboratory performance as documented in annual SC laboratory appraisals. The institutions are held accountable for responding to the peer review recommendations. Annual reviews of instrumentation projects focus on scientific merit, technical status and feasibility, cost and schedule, and effectiveness of management approach. In FY 2011, NP conducted a total of 30 reviews with panels of national and international experts. All NP baselined projects are currently on cost and on schedule. Performance of instrumentation projects is also assessed on a monthly and quarterly basis.

One of the most pressing priority-setting issues at the national user facilities is how to allocate available beam time, or time spent doing experiments on a facility's accelerator. Facility directors at the host institution (laboratory or university) seek advice from the facility's Program Advisory Committees to determine the allocation of this valuable scientific resource. The facility Program Advisory Committees review research proposals requesting resources and time at the facilities and then provide advice on the scientific merit, technical feasibility, and personnel requirements of the proposals. University grants are proposal driven. Based on peer review, NP funds the most compelling and internationally competitive ideas submitted in response to grant solicitation notices. Proposals are reviewed by external scientific peers and competitively awarded according to the guidelines published in 10 CFR 605. The quality and productivity of university grants are peer reviewed on a three-year basis with progress reports required annually. Laboratory research groups are reviewed on a four-year basis by external scientific peers, with progress reports required annually, to ensure laboratory research efforts maintain a high level of productivity on compelling, internationally competitive mission driven science. Funding decisions in this budget request are influenced by the results of these periodic peer reviews of the national laboratory research efforts. Laboratory research groups in the Low Energy subprogram were reviewed in August 2011.

Program Goals and Funding

Office of Science performance expectations (and therefore funding requests) are focused on four areas:

- *Research*: Support fundamental research to discover, explore, and understand all forms of nuclear matter.
- *Facility Operations*: Maximize the reliability, dependability, and availability of the NP scientific user and isotope production facilities.
- *Future Facilities*: Build future facilities or upgrades to existing facilities and experimental capabilities to ensure the continuing value of the NP scientific user and isotope production facilities. All construction

[a] http://dels.nas.edu/dels/rpt_briefs/advancing_nuclear_medicine.pdf

projects and MIEs are within 10% of their specified cost and schedule baselines.

- *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 which is knowledgeable in nuclear science.

Goal Areas by Subprogram

	Research	Facility Operations	Future Facilities	Workforce
Medium Energy	31%	69%	0%	0%
Heavy Ion	17%	81%	2%	0%
Low Energy	50%	28%	22%	0%
Nuclear Theory	100%	0%	0%	0%
Isotopes	24%	76%	0%	0%
Construction	0%	0%	100%	0%
Total, Nuclear Physics	32%	56%	12%	0%

Explanation of Funding and Program Changes

	(Dollars in Thousands)		
	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Medium Energy Nuclear Physics	132,577	135,260	+2,683
The increase is dominated by Other Project Costs for the 12 GeV CEBAF Upgrade project for pre-operations and commissioning according to the project baseline, and also reflects the recently increased legislative set-aside for SBIR/STTR applied to the NP program. Offsetting these increases is decreased funding relative to FY 2012 for research efforts at universities and laboratories which will focus on the implementation of the 12 GeV CEBAF Upgrade project and analysis of data from the recently completed 6 GeV program at TJNAF as well as the RHIC Spin program.			
Heavy Ion Nuclear Physics	200,594	197,201	-3,393
Funding for research efforts at universities and laboratories is reduced relative to FY 2012 and is focused on exploiting the capabilities of RHIC in the near-term and on the ongoing heavy-ion research effort at the Large Hadron Collider. Operations hours at RHIC are reduced by about 50 percent relative to FY 2012; effective operation will be achieved by combining FY 2013–FY 2014 running into a single back-to-back run bridging the two fiscal years. Partially offsetting these decreases is an increase in funding for the STAR Heavy Flavor Tracker MIE according to project plans.			

	(Dollars in Thousands)		
	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Low Energy Nuclear Physics	105,727	98,018	-7,709
Funding for research efforts at universities and laboratories is reduced relative to FY 2012, including decreases due to the closure of HRIBF in FY 2012; D&D planning continues. Research continues on making a technology choice for a future international double beta decay experiment at a deep underground site. A neutron physics program continues at the Fundamental Neutron Physics Beamline (FNPB) at the Spallation Neutron Source focused on parity violating experiments. A modest R&D effort in support of a potential neutron electric dipole moment experiment in the future continues. Funding is held flat relative to FY 2012 for the next-generation FRIB, which is supported with operating funds through a Cooperative Agreement with MSU. FY 2012 efforts, including engineering and design activities, continue in support of achieving CD-3, "Approve Construction Start." Funding also supports operations of the ATLAS facility.			
Nuclear Theory	39,407	37,179	-2,228
Funding for theoretical activities which underpin the experimental efforts throughout the NP program is reduced relative to FY 2012, as is support to maintain the National Nuclear Data Center. Funding for SciDAC is held flat with the FY 2012 level.			
Isotope Development and Production for Research and Applications	19,082	18,708	-374
Funding is reduced for research efforts on developing new techniques for production of isotopes for research and applications that are in short supply.			
Construction	50,000	40,572	-9,428
Construction (TEC) of the 12 GeV CEBAF Upgrade project continues in FY 2013, supporting the installation of the new cryomodules in the accelerator tunnel; procurement, fabrication, and installation of the Hall D experimental equipment; and upgrades to the Halls B & C experimental equipment.			
Total, Nuclear Physics	547,387	526,938	-20,449

Medium Energy Nuclear Physics
Funding Profile by Activity

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Research	37,922	37,296	35,374
Operations (TJNAF)	82,563	77,372	80,651
SBIR/STTR[a] and Other	1,648	17,909	19,235
Total, Medium Energy Nuclear Physics	122,133	132,577	135,260

[a] FY 2011 total is reduced by $12,430,000: $11,098,000 of which was transferred to the Small Business Innovation and Research (SBIR) program and $1,332,000 of which was transferred to the Small Business Technology Transfer (STTR) program. All required NP funding for SBIR/STTR is included here in FY 2012 and FY 2013.

Overview

The Medium Energy Nuclear Physics subprogram focuses primarily on questions having to do with the first scientific frontier, Quantum Chromodynamics (QCD) and the behavior of quarks inside protons and neutrons, although it touches on all three scientific frontiers. Specific questions that are addressed include:

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

One major goal, for example, is to achieve an experimental description of the substructure of the nucleon. In pursuing that goal the Medium Energy subprogram supports different experimental approaches that seek to determine such things as the distribution of up, down, and strange quarks in the nucleons; the roles of the gluons that bind the quarks; the role of the “sea” of virtual quarks and gluons, which makes a significant contribution to the properties of protons and neutrons; the effects of the quark and gluon spins within the nucleon; and the effect of the nuclear environment on the quarks and gluons. The subprogram also measures the excited states of hadrons (composite particles made of quarks, including nucleons) in order to identify which properties of QCD determine the dynamic behavior of the quarks.

The subprogram also supports investigations into a few aspects of the second scientific frontier, Nuclei and Nuclear Astrophysics, such as the question: What is the nature of the nuclear force that binds protons and neutrons into stable nuclei? Finally, this subprogram examines certain aspects of the third scientific frontier, Fundamental Symmetries and Neutrinos, including the questions: Why is there now more visible matter than antimatter in the universe? What are the unseen forces that were present at the dawn of the universe, but disappeared from view as it evolved?

Funding for this subprogram supports both research and operations of the subprogram’s primary research facility, the Continuous Electron Beam Accelerator Facility (CEBAF) at the Thomas Jefferson National Accelerator Facility (TJNAF), as well as a component of medium energy research that is carried out at the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory (BNL). CEBAF provides high quality beams of polarized electrons that allow scientists to extract information on the quark and gluon structure of protons and neutrons; it also uses polarized electrons to make precision measurements of parity violating processes that can provide information relevant to the development of the New Standard Model. These are capabilities that are unique in the world. The increase in energy supported by construction of the 12 GeV CEBAF Upgrade, opens up compelling new scientific opportunities and secures continued U.S. world leadership in this area of physics. RHIC provides colliding beams of spin-polarized protons to probe the spin structure of the proton, another important aspect of the QCD frontier. Research support at both facilities includes the laboratory and university personnel needed to implement and run experiments and to conduct the data analysis necessary to publish results. Individual experiments which address key scientific questions in the medium energy sub-program are also supported at the High Intensity Gamma Source (HIGS) at Triangle Universities Nuclear Laboratory, at Fermi National Accelerator Laboratory (Fermilab), and at several facilities in Europe. All these facilities produce beams of sufficient energy to see details smaller than the size of a nucleon. In addition, research is supported at the Research and Engineering Center at the Massachusetts Institute of Technology (MIT) which has specialized infrastructure capabilities to develop and fabricate advanced instrumentation and accelerator equipment.

The SBIR/STTR and Other category within this subprogram reflects all of the mandatory set-aside SBIR/STTR funding for the NP program, as well as funding to meet other obligations required of the NP program, including the annual Lawrence Awards and Fermi Awards for honorees selected by DOE for outstanding contributions to science.

Explanation of Funding Changes

Funding is provided for research and operations necessary to be able to implement and then exploit the new capabilities of the 12 GeV CEBAF Upgrade at the TJNAF.

(Dollars in Thousands)

	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Research	37,296	35,374	-1,922
Funding for university and laboratory research is reduced 5.8% relative to FY 2012 levels and is focused on preparations for the 12 GeV program overall and analysis of 6 GeV data. Research is also supported at universities and laboratories for efforts with polarized proton beams at RHIC. The decrease is partially offset by a small shift of a lab research effort from the Heavy Ion subprogram.			
Operations	77,372	80,651	+3,279
There are no dedicated beam hours for research in FY 2013 as the 12 GeV CEBAF Upgrade project is implemented and commissioning activities are initiated; important maintenance and improvements of the existing facility continue in preparation for post-construction operations. The majority of the increase is for Other Project Costs for the 12 GeV CEBAF Upgrade project, which is requested according to the project baseline.			
SBIR/STTR and Other	17,909	19,235	+1,326
Funds are provided for NP's mandatory contributions to the SBIR/STTR programs at recent legislatively increased levels, and for other obligations of the NP program, including continued support for annual Fermi and Lawrence Awards. Required contributions to DOE's working capital fund increase in FY 2013. In FY 2011, $11,098,000 and $1,332,000 were transferred to the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs, respectively. SBIR/STTR funding is set at 2.95% of non-capital funding in FY 2012 and 3.05% in FY 2013.			
Total, Medium Energy Nuclear Physics	132,577	135,260	+2,683

Research

Overview

Research in the Medium Energy subprogram is supported at universities and national laboratories to study QCD and the behavior of quarks inside protons and neutrons. Research groups at TJNAF, BNL, ANL, LBNL, and LANL, and about 160 scientists and 125 graduate students at 32 universities carry out research and conduct experiments at CEBAF, RHIC, and elsewhere, and participate in the development and fabrication of advanced instrumentation. These state-of-the-art detectors often have relevance to applications in medical imaging instrumentation and homeland security.

TJNAF staff research efforts include developing experiments, acquiring data, and performing data analysis in the three existing CEBAF experimental Halls. Additionally, a scientific group is being developed for the new experimental Hall D that is being constructed as part of the 12 GeV CEBAF Upgrade project. Scientists also are conducting research to identify and develop the scientific opportunities and goals for next generation facilities. An active visiting scientist program at the laboratory and bridge positions with regional universities are also supported at TJNAF, which is a cost-effective approach to augmenting scientific expertise at the laboratory and boosting STEM educational opportunities.

ANL scientists continue targeted experiments at TJNAF and are leading an experiment at Fermilab to distinguish the different quark contributions to the structure of the proton. ANL scientists are also using their unique laser atom-trapping technique to make a precision measurement of the atomic electric dipole moment in order to research possible explanations for the excess of matter over antimatter in the universe. The development of this technology at ANL has found practical applications in geological and environmental research, such as, in tracking ground water flows in Egypt. Research groups at BNL, LBNL, ANL, and LANL with important responsibilities in the RHIC program are supported within this subprogram to play lead roles in determining the spin structure of the proton by development and fabrication of advanced instrumentation, as well as data acquisition and analysis efforts. At LANL, scientists and collaborators are also completing the Fermilab MiniBooNE anti-neutrino running and analysis. A present intriguing discrepancy between anti-neutrino and neutrino data needs to be resolved. If these results are confirmed, they could unveil new physics beyond the Standard Model which will drive future research directions in this area. Finally, researchers at MIT are utilizing their unique expertise in the study of high current, polarized electron sources.

Accelerator R&D research proposals from universities and laboratories are evaluated by peer review under a single competition for funding under the Medium Energy and Heavy Ion subprograms. This research is to develop the needed knowledge, technologies, and trained scientists to design and build next-generation NP accelerator facilities, and is also of relevance to machines being developed by other domestic and international programs, and can lead to technological advances for a variety of applications.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	High priority research at 5 national laboratories and 40 university grants were supported at levels flat relative to FY 2010. The 6 GeV program at CEBAF in FY 2011 supported 5 experiments in Hall A, including a proton and neutron Double Virtual Compton Scattering experiment; 2 ongoing and 1 new experiment in Hall B, including the HDIce experiment; and a major part of the Qweak experiment in Hall C. In addition, preparation for the future 12 GeV physics program continued.	37,922
2012 Enacted	Funding for research was reduced relative to FY 2011. Efforts are focused on completing the highest priority 6 GeV experiments at CEBAF prior to installation of the 12 GeV Upgrade, and for support of the RHIC spin program.	37,296

Fiscal Year	Activity	Funding ($000)
2013 Request	Research funding in FY 2013 is reduced overall by 5.8% relative to FY 2012; the decrease is partially offset by a small shift of a lab research effort from the Heavy Ion subprogram. Efforts are focused on analysis of 6 GeV experiments, the implementation of instrumentation needed for the 12 GeV experimental program at TJNAF, the formation of a research group for the new experimental hall in the 12 GeV CEBAF project, and on collecting experimental data at RHIC with polarized proton beams. Support for accelerator R&D is reduced by 5.8% relative to FY 2012 and addresses high priority technological advances in superconducting radiofrequency technology, cryogenics, and other areas of importance to next-generation NP facilities.	35,374

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
University Research	19,191	19,021	17,918
National Laboratory Research			
TJNAF Research	6,495	6,550	6,172
Other National Laboratory Research	11,368	10,845	10,455
Total, National Laboratory Research	17,863	17,395	16,627
Other Research			
Accelerator R&D Research	868	880	829
Total, Research	37,922	37,296	35,374

Operations

Overview

The Continuous Electron Beam Accelerator Facility (CEBAF) at the Thomas Jefferson National Accelerator Facility (TJNAF) is a unique facility with unparalleled capabilities using polarized electron beams to study quark structure; there is no other facility in the world like it and its user community has a strong international component.

Accelerator Operations support is provided for the accelerator physicists that operate the facility as well as maintenance, power costs, capital infrastructure investments, and accelerator improvements of the complex. Investments in accelerator improvement projects are aimed at increasing the productivity, cost-effectiveness, and reliability of the facility. Support is also provided to maintain efforts in developing advances in superconducting radiofrequency (SRF) technology. The core competency in SRF technology plays a crucial role in many DOE projects and facilities outside of nuclear physics and has broad applications in medicine and homeland security. For example, SRF research and development at TJNAF has led to techniques for detection of buried land mines, and carbon nanotube and nano-structure manufacturing techniques for the manufacture of super-lightweight composites such as aircraft fuselages. TJNAF also has a core competency in cryogenics and has developed award-winning techniques that have led to more cost-effective operations at TJNAF and several other Office of Science facilities. Accelerator capital equipment investment is targeted towards instrumentation needed to support the laboratory's core competencies in SRF and cryogenics. TJNAF accelerator physicists are also strongly engaged in educating the next generation of accelerator physicists, including support for the Center for Accelerator Science at Old Dominion University (ODU) where TJNAF scientists teach courses and the laboratory jointly supports the ODU Director position.

Experimental Support is provided for the scientific and technical staff, as well as for materials and services to integrate assembly, modification, and disassembly of large and complex CEBAF experiments. Capital equipment investments for experimental support at TJNAF provide scientific instrumentation for the major experiments, including data acquisition computing and supporting infrastructure.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	CEBAF operated for 4,661 hours of beam time in support of the highest priority 6 GeV experiments.	82,563
2012 Enacted	FY 2012 funding is reduced by 6.3% relative to FY 2011, which supports running at near the maximum possible given the planned shutdown beginning in the latter half of FY 2012 as part of the 12 GeV CEBAF Upgrade project. Operations are focused on efforts to implement the highest priority experiments before the completion of the current 6 GeV experimental program. Experiments distributed among all three halls are addressing compelling physics including a precision measurement of the weak charge of the proton to help constrain new physics beyond the Standard Model, an important experiment for the laboratory's search for missing excited states of the neutron, and experiments that will help develop the laboratory's research program using the 12 GeV CEBAF Upgrade.	77,372
2013 Request	FY 2013 funding supports maintenance and improvements in the existing facility in preparation for post-construction operations, beam study activities, instrumentation implementation, and installation of the 12 GeV project. The growth in operations funding relative to FY 2012 is dominated by the initiation of pre-operations funding for the 12 GeV CEBAF Upgrade project, which is part of the baselined Total Project Cost.	80,651

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
TJNAF Accelerator Operations	50,163	49,552	50,331
12 GeV Other Project Costs (OPC)	0	0	2,500
TJNAF Experimental Support	32,400	27,820	27,820
Total, Operations (TJNAF)	82,563	77,372	80,651

Heavy Ion Nuclear Physics
Funding Profile by Activity

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Research	40,203	39,977	38,630
Operations	161,391	160,617	158,571
Total, Heavy Ion Nuclear Physics	201,594	200,594	197,201

Overview

The Heavy Ion Nuclear Physics subprogram focuses on studies of nuclear matter at extremely high densities and temperatures that are directed primarily at answering the overarching questions that define one of the three frontiers identified by NSAC—Quantum Chromodynamics (QCD). The fundamental questions addressed include:

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

A program of research on hot nuclear matter began at the Relativistic Heavy Ion Collider (RHIC) at BNL in 2000 when the first collisions were observed at beam energies ten times higher than those available at any other facility in the world. Since then collisions have been produced at beam energies exceeding the first by a factor of 3 at RHIC and about 40 at the LHC. In the debris of these collisions, researchers have seen signs of the same quark-gluon plasma that is believed to have existed shortly after the Big Bang. With careful measurements, scientists accumulate data that offer insights into the creation of the universe and begin to understand how the protons, neutrons, and other bits of normal matter developed from that plasma.

The RHIC facility places heavy ion research at the frontier of nuclear physics. RHIC serves two large-scale international experiments called PHENIX and STAR. In these experiments, scientists are attempting to determine the physical characteristics of the recently discovered perfect liquid of quarks and gluons. U.S. researchers recently discovered the antimatter partner of the helium nucleus: antihelium-4. This new particle, also known as the anti-alpha, is the heaviest antinucleus ever detected, topping a similar discovery of the anti-hypertriton last year. A 10-fold enhancement in the heavy ion beam collision rate and detector upgrades will contribute further scientific results and understanding. Accelerator R&D is conducted at RHIC in a number of advanced areas including cooling of high-energy hadron beams; high intensity polarized electron sources; and high-energy, high-current energy recovery linear (ERL) accelerators. The RHIC facility is used by about 1,200 DOE, NSF, and foreign agency supported researchers.

Participation in the heavy ion program at the Large Hadron Collider (LHC) at the European Organization for Nuclear Research (CERN) provides U.S. researchers the opportunity to search for new states of matter under substantially different initial conditions than those provided by RHIC, providing complementary information regarding the matter that existed during the infant universe. The LHC will ultimately provide a center-of-mass energy 30 times that of the highest now available at RHIC. In 2010, U.S. scientists successfully conducted first experiments using the ALICE (A Large Ion Collider Experiment) detector and the CMS (Compact Muon Spectrometer). Results from these experiments suggest that the energy lost by jets of highly energetic particles when penetrating the “perfect liquid” is different from theoretical predictions offering the potential for important scientific advances in understanding of the properties of extremely dense matter. U.S. researchers have also completed the fabrication of a large Electromagnetic Calorimeter (EMCal) detector which was installed in the ALICE experiment. First heavy ion beam operations at the LHC started in late 2010 with new results reported at the Quark Matter conference in 2011.

Explanation of Funding Changes

Funding in FY 2013 supports heavy ion research and operations at the Relativistic Heavy Ion Collider, the continuation of the STAR Heavy Flavor Tracker (HFT) MIE, and experiments at the Large Hadron Collider.

(Dollars in Thousands)

	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Research	39,977	38,630	-1,347
Research efforts at university and laboratories decrease by 5.8% relative to FY 2012 and will focus on the highest priority experiments at RHIC, as well as the commitments and experimental fees to allow U.S. researchers to exploit the ALICE EMCal MIE and other detectors at the LHC. Partially offsetting the decrease to university and laboratory research is an increase for continued fabrication of the STAR HFT MIE to detect particles containing charm quarks at RHIC as planned according to the project's performance baseline. In addition, there is a small shift of a lab research effort to the Medium Energy subprogram.			
Operations	160,617	158,571	-2,046
Reduced funding in FY 2013 will support an estimated 1,360 hours of RHIC operations for the highest priority experiments. Relative to FY 2012, this is a decrease of 1,030 hours. Effective operation will be achieved by combining FY 2013–FY 2014 running into a single back-to-back run bridging the two fiscal years. The impacts of constrained FY 2012 funding, including a voluntary reduction in force at RHIC and one-time cuts to materials and supplies, are still being assessed and may further impact FY 2013 levels of operations. Funding is also reduced for lab-wide General Purpose Equipment (GPE) at BNL.			
Total, Heavy Ion Nuclear Physics	200,594	197,201	-3,393

Research

Overview

Heavy ion research groups at BNL, LBNL, LANL, ORNL, and LLNL, and about 120 scientists and 100 graduate students at 28 universities are supported to carry out research primarily at RHIC as well as a modest program at the LHC. Some of the new research topics that will be investigated at RHIC in the next several years include determining the speed of sound in the quark-gluon plasma and trying to discover the critical point in the QCD phase diagram. Discovering the speed of sound and the QCD critical point could revolutionize the quantitative understanding of the QCD phase diagram, giving insight to the processes involved in the creation of the early universe.

The university groups provide scientific personnel and graduate students needed for running the RHIC and LHC heavy ion experiments, as well as for data analysis and publishing results, and designing and fabricating the RHIC and LHC heavy ion detector upgrades. The national laboratory scientists provide essential personnel for designing, fabricating, and operating the RHIC detectors; analyzing RHIC data and publishing scientific results; conducting R&D of innovative detector designs; project management and fabrication of MIEs; and planning for future experiments. In addition, BNL and LBNL provide substantial computing infrastructure for terabyte-scale data analysis and state-of-the-art facilities for detector and instrument development. BNL scientists continue to develop and implement new instrumentation needed to effectively utilize the RHIC beam time for research, train junior scientists, and develop the computing infrastructure used by the scientific community. At LBNL, the large scale computational system, Parallel Distributed Systems Facility (PDSF), is a major resource used for the analysis of RHIC and LHC data, in alliance with the National Energy Research Scientific Computing Center (NERSC), and LLNL computing resources are also made available for LHC data analysis.

Accelerator R&D research proposals from universities and laboratories are evaluated by peer review under a single competition for funding under the Heavy Ion and Medium Energy subprograms. This research to develop the knowledge and technologies to design and build next-generation NP accelerator facilities is also of relevance to machines being developed by other domestic and international programs, and can lead to technological advances for a variety of societal applications.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	High priority research at 5 national laboratories and 29 university grants were supported at levels flat with FY 2010. The fabrication of the EMCal MIE at ALICE at the LHC was completed below budget and ahead of schedule in FY 2011. The PHENIX Silicon Vertex Tracker (VTX) at the RHIC, which received its final funding under the Recovery Act, was also completed in FY 2011.	40,203
2012 Enacted	FY 2012 funding, at reduced levels relative to FY 2011, will maintain heavy ion research efforts and fulfill the NP commitment to the international ALICE and CMS experiments at the LHC. The PHENIX Forward Vertex Detector (FVTX) MIE received its final funding under the Recovery Act and was completed in December 2011. Important for both the heavy ion and spin programs, this detector will provide new vertex tracking capabilities to PHENIX by adding two silicon endcaps. The STAR Heavy Flavor Tracker (HFT), an MIE initiated in FY 2010, is an ultra-thin, high-precision tracking detector that will provide direct reconstruction of short-lived particles containing heavy quarks; its schedule and budget baseline were established in October 2011.	39,977

Fiscal Year	Activity	Funding ($000)
2013 Request	The FY 2013 request reduces support for heavy ion research efforts at universities and national laboratories by 5.8% relative to FY 2012. Researchers will participate at RHIC and the LHC in the collection and analysis of data, operations of newly completed scientific instrumentation, and scientific leadership essential for the implementation of the STAR HFT MIE. NP commitments for required management and operating costs to the international ALICE and CMS experiments are met. Offsetting the decrease is an increase in funding relative to FY 2012 for fabrication of the STAR HFT consistent with the approved baseline. Funding is reduced for Accelerator R&D focused on high priority activities targeted towards developing technological advances for improving the operations of current facilities and the development of next-generation facilities.	38,630

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
University Research	13,578	13,978	13,168
National Laboratory Research			
BNL RHIC Research	12,032	10,812	11,430
Other National Laboratory Research	13,074	13,582	12,491
Total, National Laboratory Research	25,106	24,394	23,921
Other Research			
Accelerator R&D Research	1,519	1,605	1,541
Total, Research	40,203	39,977	38,630

Operations

Overview

Support is provided for the operations, power costs, capital infrastructure investments, and accelerator improvement projects of the Relativistic Heavy Ion Collider (RHIC) accelerator complex at Brookhaven National Laboratory (BNL). This includes the Electron Beam Ion Source (EBIS), the Booster, and AGS accelerators that together serve as the injector for RHIC. RHIC operations allow for parallel and cost-effective operations of the NASA Space Radiation Laboratory Program, for the study of space radiation effects applicable to human space flight, and the Brookhaven Linac Isotope Producer Facility (BLIP), for the production of research and commercial isotopes critically needed by the Nation. BNL nurtures important core competencies in accelerator physics techniques, which have applications in industry, medicine, homeland security, and other scientific projects outside of NP. The RHIC accelerator physicists continue to lead the effort to address technical feasibility issues of relevance to a possible next-generation collider, including beam cooling techniques and energy recovery linacs. RHIC accelerator physicists also play an important role in the education of next generation accelerator physicists, with support of graduate students and post-doctoral associates. The laboratory supports the Center for Accelerator Science and Education (CASE) in partnership with Stony Brook University. CASE takes advantage of the collaboration with BNL by providing opportunities for students to learn on the state-of-the-art accelerators at BNL and having BNL staff teach courses and advise students.

In addition to the accelerator complex, support is provided for the operation, maintenance, improvement, and enhancement of the RHIC experimental complex, including the STAR and PHENIX detectors, the experimental halls, and the RHIC Computing Facility. The STAR and PHENIX detectors provide complementary measurements, with some overlap, in order to cross-calibrate the measurements. Instrumentation advances by this community have led to practical applications in medical imaging and homeland security.

Implementation of EBIS along with detector upgrades will allow the RHIC program to make incisive measurements leading to better insights into the discovery of strongly interacting quark gluon matter and to establish whether other phenomena, such as a color glass condensate or chiral symmetry restoration exist in nature.

Finally, NP funds BNL site-wide general purpose equipment (GPE) expenses for minor new fabrications and general laboratory equipment that is essential for maintaining the productivity and usefulness of this DOE-owned facility and for meeting its requirement for safe and reliable operations.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	RHIC operated for 3,114 hours of beam time in support of the highest priority heavy ion experiments. A reduction in support for BNL GPE efforts was the result of the overall funding constraints of the FY 2011 appropriation.	161,391
2012 Enacted	RHIC operations are supported for an estimated 2,390 hour operating schedule (58 percent utilization) in FY 2012, a decrease of more than 20% from the hours achieved in FY 2011 due to overall funding constraints of the enacted FY 2012 appropriation. Operations will be focused on addressing the highest priority scientific opportunities and goals of the heavy ion program, with very modest support included for continued R&D of luminosity enhancement technologies. Operations workforce is decreased compared to the FY 2011 level due to voluntary reductions and retirements of some laboratory staff.	160,617

Fiscal Year	Activity	Funding ($000)
2013 Request	RHIC operations are supported for an estimated 1,360 hour operating schedule (33 percent utilization) in FY 2013, a decrease of 1,030 hours from that planned in FY 2012. Increases required to restore one-time cuts made in FY 2012 and for projected staff salary and benefits increases contribute to the reduction in operating hours. Effective operation will be achieved by combining FY 2013–FY 2014 running into a single back-to-back run bridging the two fiscal years. Minimal support is continued for accelerator R&D activities focused on maintaining and improving the current operations of the facility. Support for lab-wide GPE is reduced to the FY 2011 level.	158,571

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
RHIC Operations			
RHIC Accelerator Operations	122,942	122,128	121,282
RHIC Experimental Support	36,443	35,489	35,289
Total, RHIC Operations	159,385	157,617	156,571
Other Operations (BNL GPE)	2,006	3,000	2,000
Total, Operations	161,391	160,617	158,571

Low Energy Nuclear Physics
Funding Profile by Activity

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Research	57,310	52,194	48,946
Operations (ATLAS, HRIBF, and other)	38,114	31,533	27,072
Facility for Rare Isotope Beams	10,000	22,000	22,000
Total, Low Energy Nuclear Physics	105,424	105,727	98,018

Overview

The Low Energy Nuclear Physics subprogram is the most diverse within the NP portfolio, supporting research activities aligned with scientific thrusts which focus primarily on answering the overarching questions associated with the second and third frontiers identified by NSAC.

Questions associated with the second frontier, Nuclei and Nuclear Astrophysics, include:

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

Major goals of this subprogram are to develop a comprehensive description of nuclei spanning the entire nuclear chart, to utilize rare isotope beams to reveal new nuclear phenomena and structures unlike those gleaned from studies using stable nuclei, and to measure the cross sections of nuclear reactions that power stars and spectacular stellar explosions responsible for the synthesis of the elements.

Questions addressed in the third frontier, Fundamental Symmetries and Neutrinos, which uses neutrinos and neutrons as primary probes, include:

- What is the nature of the neutrinos, what are their masses, and how have they shaped the evolution of the universe?
- Why is there now more matter than antimatter in the universe?
- What are the unseen forces that were present at the dawn of the universe but disappeared from view as the universe evolved?

Neutrinos are now known to have small but non-zero masses. The subprogram seeks to measure or set a limit on the neutrino mass and to determine if the neutrino is its own anti-particle (a Majorana particle). These neutrino properties are believed to play a role in the evolution of the cosmos. Beams of cold and ultracold neutrons will be used for precision measurements of parity-violating processes and beta-decay parameters, and to investigate the dominance of matter over antimatter in the universe in order to answer fundamental questions in nuclear and particle physics, astrophysics, and cosmology.

Two NP national user facilities have been pivotal in making progress in these frontiers and together serve a national and international community of approximately 700 users. The Argonne Tandem Linac Accelerator System (ATLAS) at Argonne National Laboratory (ANL) is used to study questions of nuclear structure by providing high-quality beams of all the stable elements up to uranium and selected beams of short-lived nuclei for experimental studies of nuclear properties under extreme conditions and reactions of interest to nuclear astrophysics. The Holifield Radioactive Ion Beam Facility (HRIBF) at Oak Ridge National Laboratory (ORNL), which ceases operation in FY 2012, will provide beams of short-lived radioactive nuclei that scientists use to study exotic nuclei that do not normally exist in nature through March 2012. HRIBF has also been used to explore reactions of interest to nuclear astrophysics and isotope production.

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

Within this subprogram, NP continues to support the LBNL 88-Inch Cyclotron jointly with the National Reconnaissance Office (NRO) and the U.S. Air Force (USAF).

Explanation of Funding Changes

National laboratory and university research supports analysis of data from ATLAS and HRIBF, collecting data at ATLAS, scientific leadership for the construction of FRIB, implementation of scientific instrumentation for neutrino physics, R&D for a next generation double beta decay experiment, conducting experiments at the FNPB, and conducting R&D and developing instrumentation for next-generation neutron experiments. Support for the ATLAS national user facility operations is maintained. Funding for D&D activities associated with the closure of the HRIBF national user facility is provided. The neutron program at the FNPB focuses on the fundamental properties of the neutron through research on parity violating experiments, and a modest R&D effort on the feasibility of setting a world leading limit on the electric dipole moment of the neutron (nEDM) continues, as recommended by NSAC, following termination of the nEDM MIE in FY 2012. Finally, funding is provided to continue the implementation of FRIB.

(Dollars in Thousands)

	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Research	52,194	48,946	-3,248
Funding for national laboratory and university research in nuclear structure, nuclear astrophysics, neutron physics, and neutrino physics is reduced by 5.8% relative to FY 2012. In addition, there is a decrease associated with the reduced research effort at HRIBF, the last year of support for the Majorana Demonstrator R&D in FY 2013, and the final year of funding in FY 2012 for the CUORE MIE for neutrinoless double beta decay. These reductions are partially offset by support for a modest R&D effort on the electric dipole moment of the neutron aimed at resolving technical challenges to inform DOE on the feasibility of a future experiment and by operations support for the KATRIN experiment to put a new limit on the neutrino mass, and the GRETINA MIE for nuclear structure research, both of which were completed in FY 2011.			
Operations	31,533	27,072	-4,461
Support is provided to maintain operations at the ATLAS national user facility. Funding associated with HRIBF in FY 2013 supports D&D-related activities following the end of its operation as a national user facility in FY 2012. The decrease in funding reflects one-time NP support of dewatering and minimal sustenance of operations activities at the Homestake Mine in South Dakota in FY 2012.			

	(Dollars in Thousands)		
	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Facility for Rare Isotope Beams	22,000	22,000	0
Funding is provided for FRIB; an assessment of the total project costs and schedule will be made at the project baseline review planned to take place in FY 2012. The FY 2013 request continues support for the FY 2012 efforts and for activities aimed at achieving final CD-3, "Approve Construction Start."			
Total, Low Energy Nuclear Physics	105,727	98,018	-7,709

Research

Overview

Low Energy research groups are supported at ANL, BNL, LBNL, LANL, LLNL, and ORNL and university grants support about 125 scientists and 100 graduate students at 35 universities. About two-thirds of the supported university scientists have conducted nuclear structure and astrophysics research using specialized instrumentation at the ATLAS and HRIBF national user facilities. The subprogram also supports a number of other targeted areas of research, and DOE-supported scientists have a lead role in developing important accelerator- and non-accelerator-based projects:

- NP is the steward for double beta decay experiments within the Office of Science. This currently includes the Cryogenic Underground Observatory for Rare Events (CUORE) experiment at the Gran Sasso Laboratory in Italy, where the U.S. has a lead role to search for evidence that the neutrino is its own antiparticle and to measure or set a limit on the effective Majorana neutrino mass and the Majorana Demonstrator R&D effort to demonstrate a proof of principle for a neutrino-less double beta decay experiment with germanium detectors. In the future, NP will assess opportunities with next-generation xenon and germanium-based double beta decay experiments. U.S. university scientists participating in the German-lead Karlsruhe Tritium Neutrino (KATRIN) experiment aim to achieve a direct determination of the mass of the electron neutrino by measuring the beta decay spectrum of tritium.
- The Fundamental Neutron Physics Beamline (FNPB) at the Spallation Neutron Source will deliver cold and ultra-cold neutrons at the highest (pulsed) intensities in the world for studying the fundamental properties of the neutron, providing experimental tests of the Standard Model.
- The neutron Electric Dipole Moment Experiment (nEDM) MIE, an R&D intensive and technically challenging discovery experiment, was terminated in FY 2012, and a modest R&D effort aimed at resolving technical challenges to inform DOE on the feasibility of a future experiment continues, consistent with recent NSAC recommendations.
- Accelerator operations are supported at two university Centers of Excellence with well-defined goals and unique physics programs, the Cyclotron Institute at Texas A&M University (TAMU) and the HIGS facility at the Triangle Universities Nuclear Laboratory (TUNL) at Duke University. At the University of Washington, infrastructure is supported to develop scientific instrumentation projects and provide technical and engineering training opportunities.
- NP continues an in-house research effort at the LBNL 88-Inch Cyclotron whose operations are partially supported by the NRO and the USAF.
- The Applications for Nuclear Science and Technology initiative (also funded under the Nuclear Theory subprogram), supports competitively awarded basic nuclear physics research that also has practical applications to other fields, including medicine, next-generation nuclear reactors, and homeland security.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	High priority research at 6 national laboratories and 54 university grants were supported at levels flat with FY 2010. The Gamma Ray Energy Tracking In-Beam Nuclear Array (GRETINA) MIE was completed on cost and schedule. It is a segmented germanium detector array with unparalleled position and energy resolution for nuclear structure studies with fast nuclear beams that will rotate among the domestic low-energy nuclear physics facilities.	57,310

Fiscal Year	Activity	Funding ($000)
2012 Enacted	The funding reduction relative to FY 2011 reflects reduced university and laboratory research, the termination of the nEDM MIE, and the ramp down of the CUORE funding profile as planned. In addition, with HRIBF's closure, researchers who conducted research at HRIBF will complete analyses of data obtained in prior years, then will begin to transition to other efforts. The ATLAS research program will achieve the highest priority scientific goals for this field and mitigate some of the impact of the reduced radioactive ion beam hours caused by the closure of HRIBF. Funding supports continuation of the Majorana Demonstrator R&D effort, and transitioning to operations of new instrumentation projects as they come on-line , including GRETINA, experiments at the FNPB, and the international KATRIN experiment.	52,194
2013 Request	University and laboratory research efforts, including support for the nuclear structure and nuclear astrophysics community to conduct research at ATLAS and support the development of FRIB, is reduced by 5.8% relative to FY 2012. In addition, the closure of HRIBF results in reduced research funding, the final year of funding for the CUORE MIE was provided in FY 2012, and the Majorana R&D effort receives its final year of funding, a decrease relative to FY 2012. Partially offsetting these decreases are increases in several areas, including operations and maintenance of the recently completed GRETINA MIE. Modest funding for R&D on the electric dipole moment of the neutron aimed at resolving technical challenges to inform DOE on the feasibility of a future experiment continues, consistent with the recent NSAC review of priorities in the U.S. neutron science portfolio. Funding for Applications of Nuclear Science and Technology is reduced 5.8% relative to FY 2012.	48,946

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
University Research	21,109	19,721	18,645
National Laboratory Research			
National Laboratory User Facility Research	10,960	9,263	7,863
Other National Laboratory Research	25,241	23,210	22,438
Total, National Laboratory Research	36,201	32,473	30,301
Total, Research	57,310	52,194	48,946

Operations

Overview

The ATLAS Facility is the premiere stable beam facility in the world. The ATLAS facility nurtures a core competency in accelerator expertise with superconducting radio frequency cavities for heavy ions that is relevant to the next generation of high-performance proton and heavy-ion linacs, and is important to the Office of Science mission and international stable and radioactive ion beam facilities. ANL accelerator physicists and scientists are working closely with MSU researchers in the development and fabrication of components for FRIB.

ATLAS provides stable and selected radioactive beams coupled to specialized instrumentation for scientists to conduct nuclear structure studies. Capital equipment investments support the fabrication and implementation of small-scale instrumentation at the facility, including HELIOS, which is a novel spectrometer that probes the structure of exotic nuclei. Short-lived and very unstable intermediate nuclei are very important in the synthesis of heavier elements from lighter elements in stellar cores and explosions. To study them requires accelerators capable of producing beams composed of radioactive ions. The Californium Rare Ion Breeder Upgrade (CARIBU) source at ATLAS provides limited capabilities to produce radioactive ion beams, while FRIB will be the world-leading facility for rare ion beams when operational at the end of the decade.

Operation of HRIBF is supported through March 2012 to provide unique capabilities for the production of intense radioactive beams by the Isotope-Separator-On-Line (ISOL) technique, and for reaccelerating medium mass nuclei to the Coulomb barrier. Core competencies developed through this research have included high power target design and ISOL ion beam production techniques that will have importance for the future Facility for Rare Isotope Beams and other rare isotope beam facilities.

Limited operations of the 88-Inch Cyclotron at the Lawrence Berkeley National Laboratory (LBNL) are supported in partnership with the NRO and the USAF to meet national security needs and for a small in-house research program.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	ATLAS, which possesses unique capabilities in an international context and has cutting edge instrumentation, was operated for 5,470 hours of beam time and HRIBF for 5,742 hours of beam time in support of the highest priority nuclear structure and nuclear astrophysics experiments. ATLAS is commissioning CARIBU to enhance the radioactive beam capabilities and productivity of ATLAS. Joint support continued with the NRO and USAF for the 88-Inch Cyclotron. NP prepositioned $500,000 to support minimal, sustaining operations awaiting the final FY 2012 appropriation for DOE-supported activities at the Homestake mine in South Dakota; the funding was used for this purpose after passage of the appropriation.	38,114
2012 Enacted	ATLAS accelerator operations and experimental support funding provides for 5,900 beam hours of operation and continued cost-effective 7 day-a-week operations and maintains support for scientific and technical personnel required to operate the facility, and capital and accelerator investments focused on increasing the reliability and efficiency of operations, including helium compressors and cryogenic system upgrades. HRIBF funding is significantly reduced relative to FY 2011 as it continues limited operations through March 2012 to complete the highest priority experiments prior to its closure; D&D planning activities commence in FY 2012. Support continues at reduced levels for joint operations of the 88-Inch Cyclotron with the NRO and USAF. $4,500,000 is provided to support sustaining operations at the Homestake mine; an additional $9,500,000 is provided from the High Energy Physics program.	31,533

Fiscal Year	Activity	Funding ($000)
2013 Request	ATLAS operations and experimental support funding levels provide 4,000 hours of operations, 80% of the maximum 5,000 hours possible with the scheduled installation of facility upgrades in FY 2013. Accelerator and capital investments support continuation of the energy and efficiency upgrade of ATLAS and the development of an electron beam ion source in order to conduct experiments with more neutron rich nuclei. Most of the increase for ATLAS Operations reflects a one-time FY 2012 transfer to the Isotope subprogram for R&D in support of the development of a californium-252 target for CARIBU. Support is provided for D&D planning activities at HRIBF. Support continues at the same level as FY 2012 for joint operations of the 88-Inch Cyclotron with the NRO and USAF. The overall funding reduction relative to FY 2012 is largely due to one-time NP funding for dewatering and sustaining operations at the Homestake Mine in FY 2012.	27,072

(Dollars in Thousands)

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
User Facility Operations			
ATLAS Operations	16,196	16,048	16,429
HRIBF Operations	17,165	6,821[a]	0
HRIBF D&D Planning	0	0	6,479
Total, User Facility Operations	33,361	22,869	22,908
Other Operations	4,753	8,664	4,164
Total, Operations	38,114	31,533	27,072

[a] A portion of the FY 2012 funding is also being utilized for D&D planning activities as the facility prepares to cease operations in March 2012.

Facility for Rare Isotope Beams

Overview

The Facility for Rare Isotope Beams (FRIB) at Michigan State University (MSU) will enable world-leading research opportunities in nuclear structure, nuclear astrophysics, and fundamental symmetry studies, and complement other rare isotope beam research programs at facilities elsewhere in the world. MSU is undertaking a comprehensive effort to design, construct, and operate FRIB, which includes utilizing core competencies developed by other NP-supported national laboratory groups.

This proposed facility is to provide intense beams of rare isotopes for a wide variety of studies that will advance knowledge of the origin of the elements and the evolution of the cosmos. It offers a laboratory for exploring the limits of nuclear existence and identifying new phenomena, with the possibility that a broadly applicable theory of the structure of nuclei will emerge. The facility will offer new glimpses into the origin of the elements by leading to a better understanding of key issues by creating exotic nuclei that, until now, have existed only in nature's most spectacular explosion, the supernova. Experiments addressing questions of the fundamental symmetries of nature will similarly be conducted through the creation and study of certain exotic isotopes. Although motivated by discovery science, the knowledge gained will also develop competencies relevant to national security applications.

FRIB is based on a heavy-ion linac with a minimum energy of 200 MeV per nucleon for all ions at beam power of 400 kW. The proposed facility will have a production area, three-stage fragment separator, three ion stopping stations, and post accelerator capabilities. It is being funded with operating expense dollars through a cooperative agreement with MSU and, therefore, is not a DOE line item construction project or capital asset. Although cooperative agreements are not included under DOE O 413.3B, the management principles of DOE O 413.3B are being followed, including the approval of Critical Decisions. As proposed, FRIB will be operated as a DOE national user facility. Consistent with 10 CFR 600, real property and equipment acquired with Federal funds shall be vested with MSU. However, such items will not be encumbered by MSU for as long as the Federal government retains an interest. When the property and equipment are no longer of interest to the government, MSU will be responsible for decontamination and decommissioning.

Critical Decision 1 (CD-1), Approve Alternative Selection and Cost Range, was signed on September 1, 2010. The preliminary total project cost (TPC) range that DOE has been planning is $500,000,000 to $550,000,000, not including the MSU cost share of $94,500,000. The TPC and cost profile are preliminary and will not be finalized until CD-2, Approve Performance Baseline, originally planned in FY 2012.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	Funds were used to support engineering and design efforts and R&D efforts.	10,000
2012 Enacted	Funds are provided to continue engineering and design efforts aimed at developing FRIB, and pursue long-lead procurements and possibly a phased construction start that will reduce project risks. The Total Project Cost and duration will be evaluated in the process of achieving CD-2, "Approve Performance Baseline" planned for FY 2012.	22,000
2013 Request	Efforts begun in FY 2012 continue, and engineering and design efforts aimed at achieving CD-3, "Approve Construction Start" are pursued.	22,000

Design and Construction Schedule

This project does not have a performance baseline. Previous dates contained in this table were preliminary estimates. Changes in the planned funding profile in FY 2012 and FY 2013 will be evaluated and reviewed, and the dates for future critical decisions will be updated based on that review.

	CD-0	CD-1	Design Complete	CD-2 / 3A	CD-3B	CD-4
FY 2011	02/09/2004	4Q FY 2010	TBD	TBD	TBD	FY 2017–2019
FY 2012	02/09/2004	9/1/2010	TBD	4Q FY 2012	TBD	FY 2018–2020
FY 2013	02/09/2004	9/1/2010	TBD	TBD	TBD	TBD

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

Funding Profile (DOE Only)

This table does not include MSU's cost share which totals approximately $31,700,000 through FY 2012.

(dollars in thousands)

	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013 Request	Outyears	Total
TEC	0	0	10,000	22,000	22,000	TBD	TBD
OPC	7,000	12,000	0	0	0	TBD	TBD
TPC	7,000	12,000	10,000	22,000	22,000	TBD	TBD

Nuclear Theory
Funding Profile by Activity

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Theory Research	34,776	32,047	30,246
Nuclear Data Activities	8,159	7,360	6,933
Total, Nuclear Theory	42,935	39,407	37,179

Overview

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

This subprogram supports one of the program's university Centers of Excellence, the Institute for Nuclear Theory (INT) at the University of Washington. Starting in FY 2010, five-year topical collaborations within the university and national laboratory communities were established to address high-priority topics in nuclear theory that merit a concentrated theoretical effort. The Nuclear Theory subprogram also operates the Nuclear Data program through the National Nuclear Data Center (NNDC), which collects, evaluates, and disseminates nuclear physics data for basic nuclear research and for applied nuclear technologies. The extensive nuclear databases maintained and continually updated by the Nuclear Data program are an international resource consisting of carefully organized scientific information gathered from over 100 years of worldwide low-energy nuclear physics experiments.

Much of the research supported by the Nuclear Theory subprogram requires extensive access to leading-edge supercomputers. One area that has a particularly pressing demand for large, dedicated computational resources is lattice quantum chromodynamics (LQCD). LQCD calculations are critical for understanding and interpreting many of the experimental results from RHIC, LHC, and CEBAF. A joint five-year High Energy Physics/NP LQCD-ext project, started in FY 2010, follows previous efforts that address the computational requirements of lattice QCD research. The national LQCD computing capability was further augmented by NP Recovery Act funding, which provided a dedicated LQCD computer at TJNAF that made extensive use of graphics processor units (GPUs). This relatively inexpensive GPU-based machine has increased the capacity for LQCD research approximately fourfold, and effectively operates currently at sustained 95 teraflops.

Explanation of Funding Changes

The funding for nuclear theory and nuclear data activities is reduced relative to FY 2012.

	(Dollars in Thousands)		
	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Theory Research	32,047	30,246	-1,801
Funding for university and national laboratory research is reduced by 5.8% relative to the FY 2012 level, while funding for SciDAC is held flat with the FY 2012 level.			
Nuclear Data Activities	7,360	6,933	-427
Funding is reduced by 5.8% relative to the FY 2012 level for university and national laboratory research.			
Total, Nuclear Theory	39,407	37,179	-2,228

Theory Research

Overview

The Nuclear Theory subprogram supports the research programs of approximately 160 university scientists and 120 graduate students at 45 universities, as well as the Nuclear Theory groups at seven national laboratories (ANL, BNL, LANL, LBNL, LLNL, ORNL, and TJNAF). This research has the goals of improving our fundamental understanding of nuclear physics, interpreting the results of experiments carried out under the auspices of the experimental nuclear physics program, and identifying and exploring important new areas of research. The overall nuclear theory effort addresses the three scientific frontiers of nuclear physics: QCD, nuclear structure and astrophysics, and fundamental symmetries. It is also aligned with the experimental program through the program performance milestones established by NSAC. The need for increased support for nuclear theory activities to provide the effort necessary for the interpretation of experimental results throughout the NP program has been repeatedly stressed in successive NSAC Long Range Plans (LRPs). In FY 2010, NP implemented three new topical collaborations through 5-year awards to bring together theorists nationwide to effectively address specific high-priority theoretical challenges: JET (QCD in the heavy-ion environment); NuN (neutrinos and nucleosynthesis in hot and dense matter); and TORUS (low-energy nuclear reactions for unstable isotopes).

The national laboratory theory groups conduct broad research programs in nuclear theory, aligned to the experimental program at that laboratory, where appropriate. The base programs of the laboratory theory groups are evaluated through reviews every four years, which assess the significance of previous research accomplishments and their planned future research program, scientific leadership, creativity, productivity, and overall cost-effectiveness. The next review takes place in FY 2013.

The research effort supported by the Nuclear Theory subprogram is strengthened by interactions with NSF-supported theory efforts, the DOE HEP program, and other national nuclear theory programs. International visits by nuclear theorists are supported by three reciprocal visitor programs: Japan-U.S. (JUSTIPEN), France-U.S. (FUSTIPEN), and German-U.S (GAUSTEQ).

SciDAC is a collaborative program promoted by ASCR that partners scientists and computer experts in research teams to address major scientific challenges that require supercomputer facilities at the current technological limits, and is supported within the Nuclear Theory subprogram. The NP SciDAC program operates on a five year cycle, and supports computationally intensive research projects jointly with other SC and DOE offices in areas of mutual interest. SciDAC -2 ended in FY 2011 and programs throughout SC are being recompeted in FY 2012 as SciDAC-3.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	Theoretical research at 7 national laboratories and 81 university grants were supported; 5 scientific computing projects were supported by NP under SciDAC-2 at 7 national laboratories and 2 universities. The NP SciDAC-2 initiative that ended in FY 2011 primarily involved collaborations with ASCR, HEP, and NNSA, and supported five projects on low energy nuclear structure and nuclear reaction theory (UNEDF), lattice quantum chromodynamics (LQCD), nuclear astrophysics (CAC), advanced accelerator design (ComPASS), and grid computing (OSG).	34,776
2012 Enacted	Funding is reduced relative to FY 2011, reflecting a decrease in the NP contribution to the SciDAC initiative, and a reduction in funding for research efforts. Support is continued as planned for the second-generation LQCD project in partnership with the DOE HEP program, and third-year funding is provided for the topical theory collaborations. SciDAC programs throughout SC are being recompeted in FY 2012 as SciDAC-3. NP plans to support up to four computational nuclear theory projects under SciDAC-3 in collaboration with ASCR, HEP, and other DOE offices.	32,047

Fiscal Year	Activity	Funding ($000)
2013 Request	Support for university and laboratory theoretical efforts required for the interpretation of experimental results obtained at NP facilities is reduced by 5.8% relative to FY 2012. A specific focus will be to provide theoretical support for the research program at the upgraded CEBAF 12 GeV facility and the planned FRIB facility in order to fully exploit their physics potentials and to advance theoretical concepts that motivate future experiments at these facilities and elsewhere, including in the relatively new NP area of fundamental symmetries. Funding for SciDAC research under the SciDAC-3 program continues flat with the FY 2012 level. The fourth year for the topical theory collaborations is supported and some funding for these efforts shifts from universities to national laboratories, as planned.	30,246

(Dollars in Thousands)

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
University Research	16,389	16,361	14,873
National Laboratory Research	15,787	14,686	14,373
SciDAC	2,600	1,000	1,000
Total, Theory Research	34,776	32,047	30,246

Nuclear Data

Overview

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

Independent of the core Nuclear Data activities, funding is also included to support initiatives in Applications of Nuclear Science and Technology, including efforts relevant to nuclear fuel cycle research. This initiative is funded from both the Low Energy subprogram and the Nuclear Data program, and funding is split between the two pending competitive peer review and award.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	The Nuclear Data program continued updating online databases on experimental and evaluated nuclear structure data, nuclear reaction cross sections, and nuclear science literature. Competitive awards for the Applications of Nuclear Science and Technology initiative were made for: nuclear data cross section measurement and evaluation, fission product data, collaborative awards in neutron spectroscopy, and collaborative awards in reactor decay heat.	8,159
2012 Enacted	Funding for ongoing work of the National Nuclear Data Program is reduced relative to FY 2011. In addition, funding for new competitively awarded Applications of Nuclear Science and Technology research is reduced by roughly 25 percent.	7,360
2013 Request	Funding for the Nuclear Data program is reduced 5.8% relative to FY 2012. Efforts will be focused on updating online databases containing experimental and evaluated nuclear structure data, nuclear reaction cross sections, and nuclear science literature. The NNDC plans to hold a major nuclear data conference, ND2013, during FY 2013. Funding for Applications of Nuclear Science and Technology is reduced 5.8% relative to FY 2012.	6,933

Isotope Development and Production for Research and Applications
Funding Profile by Activity

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Research	4,060	4,827	4,453
Operations	15,610	14,255	14,255
Total, Isotope Development and Production for Research and Applications	19,670	19,082	18,708

Overview

The Isotope Development and Production for Research and Applications subprogram (Isotope Program) supports the production, distribution, and development of production techniques for radioactive and stable isotopes that are in short supply and critical to the Nation. Isotopes are commodities of strategic importance for the Nation that are essential for energy exploration and innovation, medical applications, national security, and basic research. An important goal of the program is to make key isotopes more readily available to meet domestic U.S. needs. To achieve this goal, the program provides facilities and capabilities for the production of research and commercial stable and radioactive isotopes, scientific and technical staff associated with general isotope research and production, and a supply of critical isotopes. The subprogram also supports R&D efforts associated with developing new and more cost-effective and efficient production and processing techniques, and on the production of isotopes needed for research purposes.

The Isotope Program, which operates under a revolving fund, maintains its financial viability by utilizing a combination of appropriations and revenues from the sale of isotopes and services. These resources are used to maintain the staff, facilities, and capabilities at user-ready levels and to support peer-reviewed research and development activities related to the production of isotopes. Commercial isotopes are priced to provide full cost recovery. Research isotopes are priced at lower rates to facilitate scientific advances and are now sold at a unit price, as opposed to a batch price. Investments in new capabilities are made to meet the growing demands of the Nation and foster research in applications that will support national security and the health and welfare of the public.

Isotopes are critical national resources that are used to improve the accuracy and effectiveness of medical diagnoses and therapy, enhance national security, improve the efficiency of industrial processes, and provide precise measurement and investigative tools for materials, biomedical, environmental, archeological, and other research. Some examples are: strontium-82 use for cardiac imaging; germanium-68 use for calibrating the growing numbers of positron imaging scanners; actinium-225 and bismuth-213 use in cancer and infectious disease therapy research; strontium-90 use for cancer therapy; selenium-75 use in industrial radiography; arsenic-73 use as a tracer for environmental research; silicon-32 use in oceanographic studies related to climate modeling; californium-252 for medicine, homeland defense, and energy security; and nickel-63 use as a component in molecular sensing devices and helium-3 as a component in neutron detectors, both for applications in homeland defense.

Stable and radioactive isotopes are vital to the mission of many Federal agencies including the National Institutes of Health, the National Institute of Standards and Technology, the Environmental Protection Agency, the Department of Agriculture, the Department of Homeland Security, the National Nuclear Security Administration (NNSA), and other Office of Science programs. NP continues to work in close collaboration with these federal agencies to develop strategic plans for isotope production and to establish effective communication to better forecast isotope needs and leverage resources. For example, a five-year production strategy has been generated with the National Institutes of Health (NIH) which identifies the isotopes and projected quantities needed by the medical community in the context of the

Isotope Program capabilities. Moreover, NP initiated a workshop attended by representatives of all federal agencies that require stable and radioactive isotopes to support research and applications within their realms of responsibility to provide a comprehensive assessment of national needs for isotope products and services. Another example is participation in the OSTP working group on molybedenum-99 (Mo-99) and offering technical and management support. While the Isotope Program is not responsible for the production of Mo-99, it recognizes the importance of this isotope for the Nation and is working closely with NNSA, the lead entity responsible for domestic Mo-99 production. SC is also participating in the international High-Level Group on the Security of Supply of Medical Isotopes lead by the Organisation for Economic Co-operation and Development (OECD) on Radioisotopes. NP also participates in the Certified Reference Material Working Group which assures material availability for nuclear forensics applications that support national security missions. Finally, NP plays a lead role in a federal working group on the He-3 supply issue involving staff from NNSA, the Department of Homeland Security, the Department of Defense, the Institutes of Health and many other agencies. While the Isotope Program role in helium-3 (He-3) is limited to packaging and distribution of the isotope, the program does play a lead role in working with all of the federal agencies in forecasting demand for the gas. The objective of the working group is to ensure that the limited supply of He-3 will be distributed to the highest priority applications and basic research.

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

Explanation of Funding Changes

Support is maintained for the research and development of new isotope production techniques, the mission readiness of the production and processing facilities within the program's portfolio, and for the staffing at the National Isotope Development Center.

(Dollars in Thousands)

	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Research	4,827	4,453	-374
University and laboratory research is reduced 5.8% relative to FY 2012. In addition, there is a decrease reflecting support in FY 2012 for a one-time R&D effort in support of the development of a californium-252 target for the CARIBU upgrade at ATLAS.			
Operations	14,255	14,255	0
Operations are maintained at the same funding level as FY 2012 for the Isotope Production Facility and Brookhaven Linac Isotope Producer, as well as processing capabilities at ORNL. Funding is maintained for the National Isotope Development Center, a virtual service center which coordinates DOE isotope production across the federal and academic community.			
Total, Isotope Development and Production for Research and Applications	19,082	18,708	-374

Research

Overview

Research is supported to identify, design, and optimize production targets and separation methods. Examples for planned research include the need for positron-emitting radionuclides to support the rapidly growing area of medical imaging using positron emission tomography (PET), development of isotopes that support medical research used to diagnose and treat diseases spread through acts of bioterrorism, development of production methods for alpha-emitting radionuclides that exhibit great potential in disease treatment, development and use of research isotopes for various biomedical applications, development of stable isotope enrichment technologies, and the need for alternative isotope supplies for national security applications and advanced power sources. Priorities in research isotope production are informed by guidance from NSAC. One of the highest priorities is to conduct R&D aimed at re-establishing a domestic capability for stable isotope production in the U.S. All R&D activities are peer reviewed.

Support is provided for scientists at universities, industry, and BNL, LANL, ORNL, INL, PNNL, and ANL to perform peer-reviewed experimental research on targets, separation technology maturation and development of isotope production techniques, and for the production of research isotopes at more affordable rates to the researcher. Research and development also includes target design, enhanced processing techniques, radiochemistry, material conversions, and other related services. Researchers provide unique expertise and facilities for data analysis. R&D activities utilize reactor and accelerator capabilities throughout the DOE complex and at university sites.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	A Funding Opportunity Announcement (FOA) soliciting competitive R&D proposals for new isotope production techniques resulted in 35 applicants, of which 4 projects were funded in FY 2011 based on peer review.	4,060
2012 Enacted	Based on the FY 2011 FOA, 4 research projects were awarded with FY 2012 funding. Increased funding above FY 2011 reflects modest support to establish laboratory research groups at those sites in which production capabilities exist; some funding is shifted from Operations to Research reflecting this effort. In addition, funding was provided for a one-time R&D effort for the californium-252 target for the CARIBU upgrade at ATLAS.	4,827
2013 Request	Funding for competitively awarded research and development is reduced by 5.8%; support for laboratory research groups at LANL, BNL and ORNL will continue at the same funding level as FY 2012. There is an additional reduction relative to FY 2012 as a result of the one-time R&D project for ATLAS that was funded in FY 2012.	4,453

(Dollars in Thousands)

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
National Laboratory Research	1,530	3,677	3,370
University Research	2,530	1,150	1,083
Total, Research	4,060	4,827	4,453

Operations

Overview

This Isotope Program is steward of the Isotope Production Facility (IPF) at Los Alamos National Laboratory (LANL) and the Brookhaven Linac Isotope Producer (BLIP) facility, and provides support for hot cell facilities for processing and handling irradiated materials and purified products at ORNL, BNL, and LANL. Facilities at other national laboratories are used as needed, such as the production of isotopes at the Idaho National Laboratory reactor and processing and packaging strontium-90 at the Pacific Northwest National Laboratory.

Funding is provided for the scientists and engineers needed to support operational readiness of the Isotope Program facilities, and includes modest facility maintenance and investments in new facility capabilities. In addition, the program also supports isotope production capabilities at a few university, other national laboratory, and reactor facilities throughout the Nation to promote a reliable supply of domestic isotopes. Facilities at Washington University, the University of California at Davis, the University of Washington, and the Missouri University Research Reactor, can provide cost-effective opportunities to partner in order to increase the availability of isotopes. Partnerships with industrial counterparts are pursued to leverage resources.

The National Isotope Development Center (NIDC) at ORNL interfaces with the user community and manages the coordination of isotope production across the facilities and business operations involved in the production, sale, and distribution of isotopes. The NIDC oversees public outreach for the program and has recently unveiled a new website for the program at www.isotopes.gov. The NIDC has also accepted a coordinating role for all transportation issues within the program and now coordinates these efforts among all of the production sites. The NIDC also coordinates quality control issues across all the production sites.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	Substantial quantities of radioactive and stable isotopes were produced and distributed to support commercial uses and research applications, most prominently strontium-82, germanium-68, californium-252, actinium-225, nickel-63, and selenium-75.	15,610
2012 Enacted	Mission readiness is maintained, within constrained funding, for isotope production at university and laboratory accelerator and reactor facilities, and the NIDC. Isotopes produced at these facilities will primarily be those produced in FY 2011 with additional commercial isotope production initiated in response to sufficient customer demand (e.g., gadolinium-153, strontium-89, neptunium-236, carbon-14, tin-117m) and high priority isotopes identified by NSAC (e.g., astatine-211, actinium-225, berkelium-249). Some funding is shifted to Research to support R&D activities at the national laboratories.	14,255
2013 Request	Mission readiness for isotope production at university and laboratory accelerator and reactor facilities, and support for the NIDC are maintained within flat funding with FY 2012. The isotopes that will be chosen for production will represent a balance of commercial isotopes that must be produced in order to maintain the program’s livelihood, and high priority research isotopes identified by NSAC and the Federal workshop held in FY 2012.	14,255

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
University Operations	202	150	150
Isotope Production Facility (IPF) Operations	1,041	941	941
Brookhaven Linear Isotope Producer (BLIP) Operations	520	520	520
National Isotope Data Center (NIDC)	2,162	2,278	2,278
Other National Laboratory Operations	11,685	10,366	10,366
Total, Operations	15,610	14,255	14,255

Construction
Funding Profile by Activity

(Dollars in Thousands)

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
06-SC-01, 12 GeV CEBAF Upgrade, TJNAF	35,928	50,000	40,572

Overview

This subprogram provides for Project Engineering and Design (PED) and Construction needed to meet overall objectives of the Nuclear Physics program. Currently the only line item construction project that is being supported is the 12 GeV CEBAF Upgrade at TJNAF (see construction project data sheet at the end of the NP narrative).

Explanation of Funding Changes

In FY 2013, funding is requested to continue construction of the 12 GeV CEBAF Upgrade. The upgrade was identified in the 2007 NSAC Long-Range Plan as the highest priority for the U.S. Nuclear Physics program. The upgrade will enable scientists to address one of the mysteries of modern physics—the mechanism of quark confinement.

The FY 2012 appropriation necessitates a review during FY 2012 to evaluate the impact of the FY 2012 funding level, including possible schedule delays and increased project costs.

(Dollars in Thousands)

	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
06-SC-01, 12 GeV CEBAF Upgrade, TJNAF	50,000	40,572	-9,428

In FY 2013, funding is requested according to the approved 12 GeV CEBAF Upgrade project baseline plan, which is a decrease of $9,428,000 (TEC) relative to the FY 2012 appropriation.

Supporting Information

Operating Expenses, Capital Equipment and Construction Summary

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Operating Expenses	456,552	473,154	461,501
Capital Equipment	27,029	18,611	19,243
General Plant Projects	2,891	2,000	2,000
Accelerator Improvement Projects	5,284	3,622	3,622
Construction (12 GeV Upgrade)	35,928	50,000	40,572
Total, Nuclear Physics	527,684	547,387	526,938

Funding Summary

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Research	173,525	170,115	160,182
Scientific User Facilities Operations	275,309	257,858	253,651
Other Facility Operations	20,363	22,919	24,898
Projects			
Major Items of Equipment	8,505	3,586	4,400
Facility for Rare Isotope Beams[a]	10,000	22,000	22,000
Construction Projects (12 GeV Upgrade)	35,928	50,000	40,572
Total Projects	54,433	75,586	66,972
Other	4,054[b]	20,909	21,235
Total Nuclear Physics	527,684[b]	547,387	526,938

[a] FRIB is being funded with operating expense dollars through a Cooperative Agreement with Michigan State University (MSU).

[b] Total reduced by $12,430,000: $11,098,000 of which was transferred to the Small Business Innovation and Research (SBIR) program and $1,332,000 of which was transferred to the Small Business Technology Transfer (STTR) program.

Scientific User Facilities Operations and Research

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
CEBAF (TJNAF)			
Operations[a]	82,563	77,372	80,651
Facility Research/MIEs	11,644	11,404	10,175
Total CEBAF	94,207	88,776	90,826
RHIC (BNL)			
Operations	159,385	157,617	156,571
Facility Research/MIEs	12,032	10,812	11,430
Total RHIC	171,417	168,429	168,001
HRIBF (ORNL)			
Operations[b]	17,165	6,821	0
Facility Research/MIEs	5,620	4,123	0
Total HRIBF	22,785	10,944	0
ATLAS (ANL)			
Operations	16,196	16,048	16,429
Facility Research/MIEs	5,340	5,140	4,669
Total ATLAS	21,536	21,188	21,098
Scientific User Facilities			
Operations	275,309	257,858	253,651
Facility Research/MIEs	34,636	31,479	26,274
Total Scientific User Facilities	309,945	289,337	279,925

[a] CEBAF Operations includes $2,500,000 in 12 GeV Other Project Cost funding in FY 2013.
[b] Operations of HRIBF as a National User Facility will cease in March 2012. Funding in FY 2012 will be used for D&D planning, transitioning staff, and limited operations to complete the highest priority experiments prior to closure.

Total Facility Hours and Users

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
CEBAF (TJNAF)[a]			
Achieved Operating Hours	4,661	N/A	N/A
Planned Operating Hours	4,090	3,870	0
Optimal Hours	4,090	3,940	0
Percent of Optimal Hours	114%	98%	N/A
Unscheduled Downtime	7%	N/A	N/A
Number of Users	1,370	1,390	1,390
RHIC (BNL)			
Achieved Operating Hours	3,114	N/A	N/A
Planned Operating Hours	3,210	2,390	1,360
Optimal Hours	4,100	4,100	4,100
Percent of Optimal Hours	76%	58%	33%
Unscheduled Downtime	24%	N/A	N/A
Number of Users	1,200	1,200	1,200
HRIBF (ORNL)			
Achieved Operating Hours	5,742	N/A	N/A
Planned Operating Hours	5,200	0	0
Optimal Hours	6,100	0	0
Percent of Optimal Hours	94%	N/A	N/A
Unscheduled Downtime	17%	N/A	N/A
Number of Users	300	0	0

[a] The optimal hours for CEBAF in FY 2012 and FY 2013 reflect the maximum possible due to the planned shutdown schedule associated with the 12 GeV CEBAF Upgrade project. The user community will remain involved during the shutdown in FY 2013 with instrumentation and equipment implementation.

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
ATLAS (ANL)			
Achieved Operating Hours	5,470	N/A	N/A
Planned Operating Hours	5,700	5,900	4,000
Optimal Hours	6,600	6,200	5,000[a]
Percent of Optimal Hours	83%	95%	80%
Unscheduled Downtime	7%	N/A	N/A
Number of Users	410	410	410
Total Facilities			
Achieved Operating Hours	18,987	N/A	N/A
Planned Operating Hours	18,200	12,160	5,360
Optimal Hours	20,890	14,240	9,100
Percent of Optimal Hours (funding weighted)	89%	74%	38%
Unscheduled Downtime	13%	N/A	N/A
Total Number of Users	3,280	3,000	3,000

Major Items of Equipment

(Dollars in Thousands)

	Prior Years	FY 2011 Current	FY 2012 Enacted	FY 2013 Request	Outyears	Total	Completion
Heavy Ion Nuclear Physics							
Heavy Ion LHC Experiments, LBNL							
TEC	12,000	1,205	0	0	0	13,205	4Q FY 2011
OPC	295	0	0	0	0	295	
TPC	12,295	1,205	0	0	0	13,500	
STAR Heavy Flavor Tracker, BNL							
TEC	2,400	4,400	3,050	4,400	950	15,200	4Q FY 2015
OPC	280	0	0	0	0	280	
TPC	2,680	4,400	3,050	4,400	950	16,580[b]	

[a] The optimal hours in FY 2013 reflect the maximum hours that ATLAS can operate due to the scheduled installation of upgrades.
[b] This project received CD-2/3 approval in October 2011; the TPC includes $1.1M of support for engineering and technical activities already supported by the RHIC research program.

	(Dollars in Thousands)						
	Prior Years	FY 2011 Current	FY 2012 Enacted	FY 2013 Request	Outyears	Total	Completion
Low Energy Nuclear Physics							
Neutron Electric Dipole Moment (nEDM), ORNL							
TEC	8,547	2,100	0	0	0	N/A	N/A
OPC	933	0	0	0	0	N/A	
TPC	9,480	2,100	0	0	0	N/A[a]	
Cryogenic Underground Observatory for Rare Events (CUORE), LBNL							
TEC	6,600	800	186	0	0	7,586	2Q FY 2015
OPC	764	0	350	0	0	1,114	
TPC	7,364	800	536	0	0	8,700	
Total MIEs							
TEC		8,505	3,236	4,400			
OPC		0	350	0			
TPC		8,505	3,586	4,400			

[a] nEDM is terminated as an MIE in FY 2012.

Heavy Ion Nuclear Physics MIEs

Heavy Ion LHC Experiment (ALICE EMCal), LBNL: This MIE fabricated a large electromagnetic calorimeter (EMCal) for the ALICE experiment at the LHC, and is a joint project with France and Italy. The project received CD-4 approval in September 2011, and was completed on cost and schedule.

STAR Heavy Flavor Tracker (HFT), BNL: This MIE will fabricate a high-precision tracking and vertexing device based on ultra-thin silicon pixel and pad detectors in the STAR detector. It received CD-2/3 approval in October 2011. The project is scheduled for completion in FY 2015, with an early finish planned in FY 2014.

Low Energy Nuclear Physics MIEs

Neutron Electric Dipole Moment (nEDM), ORNL: This joint DOE/NSF project to fabricate a cryogenic apparatus to measure the neutron electric dipole moment using ultra-cold neutrons from the FNPB is terminated as an MIE in FY 2012.

Cryogenic Underground Observatory for Rare Events (CUORE), LBNL: This MIE fabricates the U.S. contribution to the Italian-led CUORE experiment to measure fundamental neutrino properties. It received CD-2/3 approval in December 2009 and is scheduled to finish in FY 2015. This is a joint DOE/NSF project with NSF contributing additional funds.

Construction Projects

(Dollars in Thousands)

	Prior Years	FY 2011 Current	FY 2012 Enacted	FY 2013 Request	Outyears	Total	Completion
12 GeV CEBAF Upgrade, TJNAF							
TEC	134,500	35,928	50,000	40,572	26,500	287,500	3Q FY 2015
OPC	10,500	0	0	2,500	9,500	22,500	
TPC[a]	145,000	35,928	50,000	43,072	36,000	310,000	

Scientific Employment[b]

	FY 2011 Current (Actual)	FY 2012 Enacted (estimated)	FY 2013 Request (estimated)
# University Grants	225	215	205
Average Size per year	$315,000	$315,000	$300,000
# Laboratory Projects	34	34	33
# Permanent Ph.D.s	725	715	645
# Postdoctoral Associates	359	350	315
# Graduate Students	538	530	475
# Ph.D.s awarded	86	80	80

[a] The TPC reflects the current baseline and does not reflect impacts of reduced FY 2012 funding.

[b] This table does not include approximately 1,100 engineering, technical, and administrative FTEs that were supported by the NP program in FY 2011. Comparable reductions in the number of supported FTEs are likely among this group as projected for PhDs, postdocs and graduate students in FY 2012 and FY 2013. An additional 27 Ph.D.s, 16 Postdoctoral Associates, and 13 graduate students were supported with Recovery Act funds in FY 2011.

06-SC-01, 12 GeV CEBAF Upgrade, Thomas Jefferson National Accelerator Facility
Newport News, Virginia
Project Data Sheet is for PED/Construction

1. Significant Changes

The most recent DOE O 413.3B approved Critical Decision (CD) is CD-3, Approve Start of Construction, which was signed on September 15, 2008, with a Total Project Cost (TPC) of $310,000,000 and a planned CD-4 in 3Q FY 2015.

A Federal Project Director at the appropriate level is assigned to this project.

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

This PDS is an update of the FY 2012 PDS. A baseline change will be required as a result of the recently enacted FY 2012 Consolidated Appropriations Act which provided $50,000,000 for this project, $16,000,000 less than the baseline profile. Changes in project cost or schedule resulting from the FY 2012 funding have not yet been evaluated and reviewed and are not reflected in this PDS. It is expected that a new baseline will be established by the end of FY 2012. The project continues to manage all identified risks. Risks change from month to month, and include issues with the procurement and installation of components, overall staffing levels and schedule, impacts of continuing resolutions, and claims from subcontractors. For each moderate and high risk a mitigation plan is developed in order to assure successful project completion.

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

(fiscal quarter or date)

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

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

[a] CD-1 was approved on 2/14/2006. Engineering and design activities started in 4Q FY 2006 after Congress approved the Department of Energy's request to reprogram $500,000 within the FY 2006 funding for Nuclear Physics, per direction contained in H.Rpt 109–275.
[b] The CD-4A and CD-4B dates reflect the original baseline schedule and do not reflect impacts of reduced FY 2012 funding which may require schedule revision.

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	21,000	TBD	TBD	11,000	TBD	TBD	TBD
FY 2008	21,000	TBD	TBD	10,500	TBD	TBD	TBD
FY 2009	21,000	266,500	287,500	22,500	N/A	22,500	310,000
FY 2010	21,000	266,500	287,500	22,500	N/A	22,500	310,000
FY 2011	21,000	266,500	287,500	22,500	N/A	22,500	310,000
FY 2012	21,000	266,500	287,500	22,500	N/A	22,500	310,000
FY 2013	21,000	266,500	287,500	22,500	N/A	22,500	310,000[a]

4. Project Description, Scope, and Justification

Mission Need

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

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

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

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

[a] A Work-for-Others agreement was approved by DOE that provides $9,000,000 to leverage the federal investment of $310,000,000 for an upgrade of the Jefferson Lab's research facilities. The additional funding reduces project risks associated with cost and schedule and helps ensure timely completion of the project. Any adjustments to the federal government's share of the TPC as a result of the funding from this Work-for-Others activity will be evaluated by the SC Office of Project Assessment during the review that assesses the impacts of reduced FY 2012 funding which may result in a change to the TPC.

CD-4A Key Performance Parameters

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

CD-4B Key Performance Parameters

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

Key Performance Parameters to achieve CD-4, *Approve Start of Operations or Project Closeout*, are phased around the accelerator and conventional facilities (CD-4A) and the experimental equipment in Halls B, C, and D (CD-4B). The deliverables defining completion are identified in the Project Execution Plan and have not changed since CD-2. Mitigation plans exist to help ensure that the two high risk and eleven moderate risks will not impact the planned completion dates.

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

5. Financial Schedule

(dollars in thousands)

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

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

(dollars in thousands)

	Appropriations	Obligations	Recovery Act Costs	Costs
Construction				
FY 2009	28,500	28,500	0	5,249
FY 2009 Recovery Act	65,000	65,000	2,738	0
FY 2010	20,000	20,000	29,621	18,642
FY 2011[a]	35,928	35,928	25,889	40,801
FY 2012	50,000	50,000	6,752	61,249
FY 2013	40,572	40,572	0	49,000
FY 2014	26,500	26,500	0	23,500
FY 2015	0	0	0	3,059
Total, Construction[b]	266,500	266,500	65,000	201,500
TEC				
FY 2006	500	500	0	88
FY 2007	7,000	7,000	0	6,162
FY 2008	13,377	13,377	0	9,108
FY 2009	28,623	28,623	0	10,619
FY 2009 Recovery Act	65,000	65,000	2,738	0
FY 2010	20,000	20,000	29,621	18,907
FY 2011[a]	35,928	35,928	25,889	40,808
FY 2012	50,000	50,000	6,752	61,249
FY 2013	40,572	40,572	0	49,000
FY 2014	26,500	26,500	0	23,500
FY 2015	0	0	0	3,059
Total, TEC[b]	287,500	287,500	65,000	222,500

[a] The FY 2011 funding was reduced by $72,000 as a result of the FY 2011 rescission.
[b] The TEC total reflects the original baseline. The FY 2012 reduction is restored in FY 2014 as a placeholder pending a baseline review and assessment.

(dollars in thousands)

	Appropriations	Obligations	Recovery Act Costs	Costs
Other Project Cost (OPC)				
OPC except D&D				
FY 2004	700	700	0	77
FY 2005	2,300	2,300	0	2,142
FY 2006	4,000	4,000	0	3,508
FY 2007	2,500	2,500	0	2,751
FY 2008	1,000	1,000	0	1,802
FY 2009	0	0	0	155
FY 2010	0	0	0	62
FY 2013	2,500	2,500	0	2,403
FY 2014	7,500	7,500	0	7,000
FY 2015	2,000	2,000	0	2,600
Total, OPC	22,500	22,500	0	22,500
Total Project Cost				
FY 2004	700	700	0	77
FY 2005	2,300	2,300	0	2,142
FY 2006	4,500	4,500	0	3,596
FY 2007	9,500	9,500	0	8,913
FY 2008	14,377	14,377	0	10,910
FY 2009	28,623	28,623	0	10,774
FY 2009 Recovery Act	65,000	65,000	2,738	0
FY 2010	20,000	20,000	29,621	18,969
FY 2011[a]	35,928	35,928	25,889	40,808
FY 2012	50,000	50,000	6,752	61,249
FY 2013	43,072	43,072	0	51,403
FY 2014	34,000	34,000	0	30,500
FY 2015	2,000	2,000	0	5,659
Total, TPC[b]	310,000	310,000	65,000	245,000

[a] The FY 2011 funding was reduced by $72,000 as a result of the FY 2011 rescission.
[b] The TPC total reflects the original baseline. The FY 2012 reduction is restored in FY 2014 as a placeholder pending a baseline review and assessment.

6. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Estimate
Total Estimated Cost (TEC)			
Design (PED)			
Design	21,000	21,000	19,200
Contingency	0	0	1,800
Total, PED (PED no. 06-SC-01)	21,000	21,000	21,000
Construction Phase			
Civil Construction	29,507	31,880	27,450
Accelerator/Experimental Equipment/ Management	210,058	191,463	174,150
Contingency	26,935	43,157	64,900
Total, Construction	266,500	266,500	266,500
Total, TEC	287,500	287,500	287,500
Contingency, TEC	26,935	43,157	66,700
Other Project Cost (OPC)			
OPC except D&D			
Conceptual Design	3,445	3,445	3,500
R&D	7,052	7,052	6,400
Start-up	9,394	8,195	7,450
Contingency	2,609	3,808	5,150
Total, OPC	22,500	22,500	22,500
Contingency, OPC	2,609	3,808	5,150
Total, TPC	310,000	310,000	310,000
Total, Contingency	29,544	46,965	71,850

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 (PED only)	TEC	19,000	2,000	0	0	0	0	0	0	0	21,000
	OPC	11,000	0	0	0	0	0	0	0	0	11,000
	TPC	30,000	2,000	0	0	0	0	0	0	0	32,000
FY 2008 (PED only)	TEC	21,000	0	0	0	0	0	0	0	0	21,000
	OPC	10,500	0	0	0	0	0	0	0	0	10,500
	TPC	31,500	0	0	0	0	0	0	0	0	31,500
FY 2009[a] (Perfor-mance Baseline)	TEC	20,877	28,623	0	59,000	62,000	66,000	40,500	10,500	0	287,500
	OPC	10,500	0	0	0	0	0	2,500	7,500	2,000	22,500
	TPC	31,377	28,623	0	59,000	62,000	66,000	43,000	18,000	2,000	310,000
FY 2010[b]	TEC	20,877	28,623	65,000	22,000	34,000	66,000	40,500	10,500	0	287,500
	OPC	10,500	0	0	0	0	0	2,500	7,500	2,000	22,500
	TPC	31,377	28,623	65,000	22,000	34,000	66,000	43,000	18,000	2,000	310,000
FY 2011	TEC	20,877	28,623	65,000	20,000	36,000	66,000	40,500	10,500	0	287,500
	OPC	10,500	0	0	0	0	0	2,500	7,500	2,000	22,500
	TPC	31,377	28,623	65,000	20,000	36,000	66,000	43,000	18,000	2,000	310,000
FY 2012	TEC	20,877	28,623	65,000	20,000	36,000	66,000	40,500	10,500	0	287,500
	OPC	10,500	0	0	0	0	0	2,500	7,500	2,000	22,500
	TPC	31,377	28,623	65,000	20,000	36,000	66,000	43,000	18,000	2,000	310,000
FY 2013	TEC	20,877	28,623	65,000	20,000	35,928[c]	50,000	40,572	26,500	0	287,500
	OPC	10,500	0	0	0	0	0	2,500	7,500	2,000	22,500
	TPC[d]	31,377	28,623	65,000	20,000	35,928	50,000	43,072	34,000	2,000	310,000

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

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

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

[d] The TPC total reflects the original baseline. The FY 2012 reduction is restored in FY 2014 as a placeholder, pending a baseline review and assessment.

8. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy (fiscal quarter or date)	3Q FY 2015
Expected Useful Life (number of years)	15
Expected Future start of D&D for new construction (fiscal quarter)	N/A

(Related Funding Requirements)

(dollars in thousands)

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

9. Required D&D Information

	Square Feet
Area of new construction	31,500
Area of existing facility(ies) being replaced	N/A
Area of any additional D&D space to meet the "one-for-one" requirement	31,500

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

10. Acquisition Approach

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

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

[b] The FY 2012 request to Congress incorrectly included the $310,000,000 total project cost in this total, and so reported an operations and maintenance total of $2,560,000,000.

Workforce Development for Teachers and Scientists
Funding Profile by Subprogram and Activity

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Internships and Visiting Faculty Activities at the DOE Laboratories			
Science Undergraduate Laboratory Internships	6,340	6,500	7,300
Community College Internships (formerly Community College Institute of Science and Technology)	662	600	700
Visiting Faculty Program (formerly Faculty and Student Teams)	608	1,200	1,300
Fellowships			
Albert Einstein Distinguished Educator Fellowship	1,425	1,200	1,200
DOE Office of Science Graduate Fellowship	8,000	5,000	0
National Science Bowl®	3,128	2,700	2,800
Technology Development and On-Line Application	200	551	550
Evaluation Studies	1,290	300	300
Outreach	283	300	300
Laboratory Equipment Donation Program	100	149	50
DOE Academies Creating Teacher Scientists	180	0	0
Pre-Service Teachers	324	0	0
High School Engineering	60	0	0
Total, Workforce Development for Teachers and Scientists	22,600	18,500	14,500

Public Law Authorizations

Public Law 95–91, "Department of Energy Organization Act of 1977"
Public Law 101–510, "DOE Science Education Enhancement Act of 1991"
Public Law 103–382, "The Albert Einstein Distinguished Educator Fellowship Act of 1994"
Public Law 109–58, "Energy Policy Act of 2005"
Public Law 110–69, "America COMPETES Act of 2007"
Public Law 111–358, "America COMPETES Act of 2010"

Overview and Benefits

The Workforce Development for Teachers and Scientists (WDTS) program helps ensure that DOE and the Nation have a sustained pipeline of highly skilled and diverse science, technology, engineering, and mathematics (STEM) workers. This is accomplished through support of undergraduate internships and visiting faculty programs at the DOE laboratories; the Albert Einstein Distinguished Educator Fellowship for K–12 teachers, which is administered by WDTS for DOE and for a number of other federal agencies; and Nation-wide, middle- and high-school science competitions that culminate annually in the National Science Bowl® in Washington D.C.

These investments help develop the next generation of scientists and engineers to support the DOE missions, administer its programs, and conduct the research that will realize the Nation's science and innovation agenda. Today, DOE's federal and contractor workforce includes more than 30,000 workers with STEM backgrounds; it is important to ensure the availability and readiness of DOE's future workforce.

DOE's 17 national laboratories provide a unique opportunity for STEM workforce development. The national laboratory system offers access to leading scientists; world-class scientific user facilities and instrumentation; and large-scale, multidisciplinary research programs unavailable in universities or industry. WDTS activities leverage these attributes of the DOE laboratory system to inspire, develop, and train students and educators, with the intent that they continue the pursuit of work relevant to the DOE mission in their future studies and careers.

Program Accomplishments and Milestones

The 2011 National Science Bowl®. In 2011, the number of regional events leading to the finals of the National Science Bowl® increased approximately 5% from the previous year to a total of 110. About 13,000 middle and high school students and 5,000 volunteers participated in the regional and national competitions. Changes and improvements were made in 2011 in response to recommendations from the 2010 WDTS Committee of Visitors: an energy category was added to the questions to increase alignment with DOE missions, and WDTS began efforts to increase the diversity of participants at regional competitions. In 2011, 17 of the regional events were hosted by minority serving professional organizations, including the National Organization of Black Chemists and Chemical Engineers, the Society of Hispanic Professional Engineers, and the American Indian Science and Engineering Society. Regional events were also hosted in Puerto Rico and the U.S. Virgin Islands. In 2012, WDTS will collect regional event participant demographic data using methodologies recognized as being secure and compliant, and use the data to measure minority participation.

Broadening participation in the Office of Science user facilities. The Interdisciplinary Consortium for Research and Educational Access in Science and Engineering (INCREASE) was initiated at Brookhaven National Laboratory with support from the WDTS Faculty and Student Teams activity to promote participation of STEM faculty from Historically Black Colleges and Universities and other minority-serving institutions in research performed at Office of Science user facilities. The activity has since expanded to Lawrence Berkeley National Laboratory and SLAC National Accelerator Laboratory. A primary goal is to establish leaders and role models among these faculty members by allowing them to gain the research and engineering skills required to design and use advanced instrumentation at the scientific user facilities. Targeted workshops have been held to introduce faculty to the scientific user facilities, particularly the synchrotron radiation light sources and the nanoscale science research centers. These workshops facilitate collaborations with DOE researchers, provide guidance in accessing beam time for research, and encourage full participation in the research of the scientific user facilities. This activity and others will be highlighted at a best-practices workshop sponsored by WDTS to encourage wider participation in the Visiting Faculty Program.

Longitudinal study of participants in the Science Undergraduate Laboratory Internship program. In the first longitudinal study commissioned by WDTS, 3,300 participants from the past 9 years were sent follow-up surveys. Preliminary results indicate that more than 3/4 of the respondents report pursuing STEM careers and about 2/3 of the respondents reported an increased desire to pursue graduate education in STEM as a result of their participation in the program. Additional results will be developed from the survey as part of WDTS program evaluation efforts.

Milestone	Date
The regional competitions of the National Science Bowl are completed.	2nd Qtr, FY 2012
The final competition of the National Science Bowl is completed.	3rd Qtr, FY 2012
WDTS hosts a stakeholders' meeting to finalize the changes in its activities sited at the DOE Laboratories—the Science Undergraduate Laboratory Internship, the Community College Internship, and the Visiting Faculty Program.	4th Qtr, FY 2012
WDTS hosts a best-practices workshop for the Visiting Faculty Program.	4th Qtr, FY 2012

Explanation of Changes

No funding is requested in FY 2013 for the DOE Office of Science Graduate Fellowship Program.

Program Planning and Management

In FY 2011 and continuing through FY 2013, WDTS program planning and management activities will focus on the short- and long-term recommendations of the

2010 report of the Committee of Visitors. In FY 2011, in response to general recommendations of the Committee of Visitors, senior program staff of WDTS and the Office of the Deputy Director for Science Programs initiated an assessment of WDTS activities, beginning with the activities that are executed at the DOE laboratories—the Science Undergraduate Laboratory Internship (SULI), the Community College Internship (CCI), and the Visiting Faculty Program (VFP). At a meeting with the 17 DOE Laboratory Education Directors the following were discussed for each activity: the activity goal, the activity scope, the metrics of success, and the measurement methodologies. Logic models (formalized descriptions of the connections among the activity inputs, the program itself, the outputs, and the outcomes) were created for each activity. The logic models were then used to create requirements documents for a new IT system software that will track participants from the time of their application through long-term follow up, permitting program assessment and evaluation.

As a part of the response to the recommendation of the 2010 Committee of Visitors for increased interaction and cooperation between WDTS staff and Office of Science research program staff, the Office of Science STEM Working Group was established. The Working Group, which includes Ph.D. level program managers from the SC program offices, coordinates STEM workforce activities across the Office of Science and provides a forum for sharing best practices in program management, particularly management of programs at the DOE laboratories. The STEM Working Group also coordinates with the DOE technology programs.

The Office of Science, in collaboration with the DOE technology programs, represents the Department of Energy on the interagency Committee on STEM Education (CoSTEM) established under the National Science and Technology Council. In response to the 2010 reauthorization of the America COMPETES Act, CoSTEM was formed to coordinate federal STEM education activities and programs and specifically charged to establish and maintain an inventory of federally sponsored STEM education programs and develop a 5-year STEM education strategic plan. As part of these efforts the federal agencies are identifying and sharing best practices for STEM programs, which will inform processes used by the WDTS programs. In December 2011, CoSTEM released the *Federal Science, Technology, Engineering, and Mathematics (STEM) Education Portfolio*, an inventory and analysis of Federal supported STEM education programs across 13 agencies. Through this committee and other venues, WDTS engages with the National Science Foundation, National Aeronautics and Space Administration, Department of Defense, National Institutes of Health, and other federal agencies to develop interagency efforts in STEM workforce development and education.

WDTS coordinates with other Office of Science and DOE offices in the advancement of their STEM workforce development activities. WDTS participates in the Office of Science STEM Education Working Group and communicates with counterparts in the DOE technology offices on a regular basis.

Program Goals and Funding

Office of Science performance expectations (and therefore funding requests) are focused on four areas:

- *Research*: Support fundamental research to increase our understanding of and enable predictive control of phenomena in the physical and biological sciences.
- *Facility Operations:* Maximize the reliability, dependability, and availability of the Office of Science scientific user facilities.
- *Future Facilities:* Build future and upgrade existing facilities and experimental capabilities to ensure the continuing value of the Office of Science scientific user facilities. All construction projects and MIEs are within 10% of their specified cost and schedule baselines.
- *Scientific Workforce:* Contribute to STEM workforce development through the support of undergraduate internships and visiting faculty programs at the DOE laboratories; a graduate fellowship program; the Albert Einstein Distinguished Educator Fellowship; and the National Science Bowl®.

Goal Areas

	Research	Facility Operations	Future Facilities	Scientific Workforce
Workforce Development for Teachers and Scientists	0%	0%	0%	100%

Explanation of Funding and Program Changes

	(Dollars in Thousands)		
	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Science Undergraduate Laboratory Internships	6,500	7,300	+800
The number of undergraduate students supported increases from approximately 650 to 720.			
Community College Internships (formerly Community College Institute of Science and Technology)	600	700	+100
The number of community college students supported decreases from approximately 110 to 80; FY 2012 funding was augmented with prior year funds remaining from terminated activities.			
Visiting Faculty Program (formerly Faculty and Student Teams)	1,200	1,300	+100
Funding is increased to help support students participation in the Visiting Faculty Program. Beginning in FY 2012, student participation in this program is optional and participating students, if any, who accompany faculty, are supported through this program rather than through the SULI program.			
Albert Einstein Distinguished Educator Fellowship	1,200	1,200	0
No change in funding level. Funding is provided to support 6 Fellows in FY 2013.			
DOE Office of Science Graduate Fellowship	5,000	0	-5,000
No funding is provided for this program in FY 2013.			
National Science Bowl®	2,700	2,800	+100
Funding is increased to help defray increased housing, transportation, and other logistical expenses for the national event.			
Technology Development and On-Line Application	551	550	-1
Funding is provided to support the on-line application software development and implementation for all of the WDTS programs.			
Evaluation Studies	300	300	0
Funding is provided to accommodate the integration of evaluation and workforce studies into one activity and to support a workshop and/or a review prior to the completion of the evaluation plans for all WDTS activities in FY 2013; this reassessment of evaluation activities addresses comments by the 2010 Committee of Visitors.			
Outreach	300	300	0
Funding is provided to engage in cooperative outreach programs with a focus on reaching under-served populations.			

	(Dollars in Thousands)		
	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Laboratory Equipment Donation Program	149	50	-99
Funding is reduced because the program includes support for colleges and universities only; the short-term pilot program to include support for middle schools and high schools is not continued.			
Total, Workforce Development for Teachers and Students	18,500	14,500	-4,000

Internships and Visiting Faculty Activities at the DOE Laboratories

Overview

Internships and Visiting Faculty Activities at the DOE Laboratories include the Science Undergraduate Laboratory Internships, the Community College Internships, and the Visiting Faculty Program. These activities are located at the DOE laboratories, a system of 17 laboratories unmatched in breadth with capacity for world-class, large-scale, multidisciplinary research and development; leading research facilities; and superb computational capabilities.

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

The **Community College Internship (CCI)** program goal is to encourage community college students to pursue technical careers relevant to the DOE mission by providing technical training experiences at DOE laboratories under the direction of laboratory staff who serve as advisors and mentors. The CCI program places students in paid internships in technologies supporting laboratory work under the supervision of a laboratory technician or researcher.

The **Visiting Faculty Program (VFP)** goal is to increase the research competitiveness of faculty members and their students at institutions historically underrepresented in the research community in order to expand the workforce that addresses DOE mission areas. The Visiting Faculty program provides an opportunity for faculty and students from these colleges or universities to contribute to a DOE research project. This program, formerly the Faculty and Student Team program, is being restructured to improve recruitment; improve faculty-laboratory investigator synergy; provide for optional student involvement that does not rely on SULI funding; and increase the use of the Office of Science scientific user facilities. Discussions with the DOE Laboratory Education Directors have provided innovative examples of success that may be incorporated into this WDTS activity.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	SULI supported approximately 610 students.	6,340
	CCI supported approximately 80 students.	662
	VFP supported approximately 75 faculty and their students.	608
2012 Enacted	SULI will support approximately 650 students.	6,500
	CCI will support approximately 110 students.	600
	VFP will continue to support faculty, who have the option of bringing up to two students with them. Beginning in FY 2012 student participation will be optional and participating students, if any, will be supported through this program rather than through the SULI program.	1,200
2013 Request	SULI will support approximately 720 students.	7,300
	CCI will support approximately 80 students.	700
	VFP will increase the total number of faculty and students supported by approximately 3 and 5, respectively.	1,300

Albert Einstein Distinguished Educator Fellowship

Overview

The Albert Einstein Distinguished Educator Fellowship Act of 1994 gives the Department of Energy responsibility for administering a program of fellowships for elementary and secondary school mathematics and science teachers. WDTS manages the Einstein Fellowship for the federal government and encourages participation by other federal agencies. Selected teachers spend eleven months in a Congressional office or a Federal agency. During FY 2011 through FY 2013, DOE supports 6 Fellows; each year 4–5 are placed in Congressional offices and 2–3 in DOE. Other agencies that have participated include the National Science Foundation, the National Aeronautics and Space Administration, the National Institutes of Health, the Department of Education, the National Institute of Standards and Technology, and the National Oceanic and Atmospheric Administration. The Fellows provide their educational expertise, years of experience, and personal insights to these offices and often are involved in the advancement of science, mathematics, and technology education.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	The FY 2011 appropriation supported 6 Fellows.	1,425
2012 Enacted	The FY 2012 appropriation supports 6 Fellows.	1,200
2013 Request	The FY 2013 WDTS request supports 6 Fellows.	1,200

National Science Bowl®

Overview

The DOE National Science Bowl® is a nationwide academic competition that tests students' knowledge in all areas of science. High school and middle school students are quizzed in a fast-paced, question-and-answer format similar to Jeopardy®.

DOE launched its National Science Bowl® competition in 1991 to encourage high school students who excel in science and math. The National Science Bowl's high school competition today involves more than 13,000 students. DOE introduced the National Science Bowl's competition for middle school students in 2002; it now involves more than 5,000 students. Since 1991, more than 320,000 students have participated in regional and national competitions.

The number of regional events held annually remains relatively constant, with 67 to 70 high school and 36 to 40 middle school teams participating in the national competition in recent years. Regional science bowl championship teams receive an all-expenses paid trip to Washington D.C. to compete at the national competition in May. Competing teams are composed of four students, one alternate, and a teacher who serves as an advisor and coach.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	WDTS increased the geographic coverage of the regional competitions, especially in high-need areas, in keeping with the recommendations of the 2010 Committee of Visitors.	3,128
2012 Enacted	Funding reflects travel costs for regional winners; increased travel costs for all participants; upgrades to the NSB online registration system to address increased number of participants and out-of-date technologies; and materials and supplies for the 2012 battery-powered electric model car competition that replaces the former hydrogen fuel cell-powered model car competition.	2,700
2013 Request	Funding is increased to help defray increased housing, transportation, and other logistical expenses for the national event.	2,800

Technology Development and On-line Application Systems

Overview

This activity continues modernization of on-line applications systems to enable program-wide IT architecture integration: an integrated suite of systems to support the on-line application, review, and evaluation for the WDTS programs.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	Funding in FY 2011 supported on-going upgrades of selected on-line applications and surveys that participants complete during their internship/fellowship experiences.	200
2012 Enacted	Funding in FY 2012 supports a redesign to integrate the on-line applications and surveys that participants complete during their internship/fellowship experiences; to bring the transactional web properties into alignment with the programmatic procedures, policies and protocols; and to provide users a facile interface.	551
2013 Request	Funding in FY 2013 continues on-going work.	550

Evaluation Studies

Overview

The Evaluation Studies activity supports work to assess whether WDTS programs meet established goals through the use of collection and analysis of data and other materials, including pre- and post- participation surveys, participant deliverables, and longitudinal participant surveys.

The 2010 Committee of Visitors found little evaluation of activities across WDTS, but noted that the data collection and evaluation plans under development provided some innovative options for gathering work force information and for tracking participants. In FY 2012, the suite of evaluation methodologies is being reassessed with the target of finalizing the evaluation plan for each WDTS activity in FY 2013.

Evaluation Studies is aligned with Congressional recommendations in the GPRA Modernization Act of 2010 and the 2008 Congressionally-mandated Academic Competitiveness Council initiative, which emphasized the need for federal programs (including STEM education programs) to demonstrate their effectiveness through rigorous evaluation. WDTS works cooperatively with Office of Science programs, other DOE programs, and other federal agencies through the National Science and Technology Council Committee on STEM Education to share best practices for STEM program evaluation to ensure the implementation of evaluation processes that are appropriate to the nature and scale of the program effort.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	WDTS initiated the first longitudinal survey of past program participants for a subset of WDTS programs.	1,290
2012 Enacted	FY 2012 request initiates assessment of the evaluation plans to measure the effectiveness of investments in STEM workforce development.	300
2013 Request	WDTS finalizes the evaluation plans for all WDTS activities.	300

Outreach

Overview

WDTS engages in cooperative outreach programs with other federal agencies to broaden and enhance its student internship and visiting faculty programs. The activity emphasizes outreach to under-served populations, with a goal to leverage funding and increase participation of deserving applicants. This activity also explores means to improve the quality of the experience for participants through the recruitment of scientists and engineers to serve as research advisors at host DOE laboratories.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	Funding was provided to engage in cooperative outreach programs with a focus on reaching under-served populations.	283
2012 Enacted	Funding continues the on-going program.	300
2013 Request	Funding continues the on-going program.	300

Laboratory Equipment Donation Program

Overview

The Laboratory Equipment Donation Program provides excess laboratory equipment to faculty at educational institutions for DOE-related research. Through the Energy Asset Disposal System, DOE sites identify excess equipment. Colleges and universities can then search for equipment of interest to them and apply via the website. DOE property managers approve or disapprove the applications. The equipment is free, but the receiving institution pays for shipping costs.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	Funding was continued for the on-going program.	100
2012 Enacted	Funding continues the on-going program.	149
2013 Request	Funding continues the on-going program. A reduction in funding reflects the elimination of eligibility for middle schools and high schools based on a suggestion by the 2010 Committee of Visitors.	50

Programs Not Funded in FY 2013

Overview

In FY 2012, three programs—DOE Academies Creating Teacher Scientists, Pre-Service Teachers, and High School Engineering—were terminated due to programmatic considerations and recommendations from the 2010 Committee of Visitors, and Workforce Studies was merged with Evaluation Studies.

In FY 2013, no funds are requested for the DOE Office of Science Graduate Fellowship (SCGF) program. The program began in FY 2010—80 fellows were fully funded for three years using Recovery Act funds, and 70 were funded for the first of three years with annual appropriations. In FY 2011 and FY 2012, funding continued for the 70 Fellows who were supported with annual appropriations; however, no funding was provided for new cohorts. In FY 2012, prior year funds redirected from terminated activities are used to fully fund a small FY 2012 cohort for three years.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	DOE Academies Creating Teacher Scientists	180
	Pre-Service Teachers	324
	High School Engineering	60
	Continued the 70 SCGF Fellows in the second year of their Fellowship started with the FY 2010 appropriation.	8,000
2012 Enacted	Continues the 70 SCGF Fellows in the third year of their Fellowship started with the FY 2010 appropriation. Prior year funds are used to fully fund a small FY 2012 cohort, totaling approximately 50 fellows, for three years.	5,000
2013 Request	None of these activities is funded in FY 2013.	0

Supporting Information

Operating Expenses, Capital Equipment and Construction Summary

(Dollars in Thousands)

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Operating Expenses	22,600	18,500	14,500

Science Laboratories Infrastructure
Funding Profile by Subprogram and Activity

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Infrastructure Support			
Oak Ridge Landlord	5,250	5,493	5,934
Payments in Lieu of Taxes	1,382	1,385	1,385
Facilities and Infrastructure	0	0	900
Total, Infrastructure Support	6,632	6,878	8,219
Construction			
Utilities Upgrade at FNAL (13-SC-70)	0	0	2,500
Utility Infrastructure Modernization at TJNAF (13-SC-71)	0	0	2,500
Science and User Support Building at SLAC (12-SC-70)	0	12,086	21,629
Research Support Building and Infrastructure Modernization at SLAC (10-SC-70)	40,694	12,024	36,382
Energy Sciences Building at ANL (10-SC-71)	14,970	40,000	32,030
Renovate Science Laboratories, Phase II, at BNL (10-SC-72)	14,970	15,500	14,530
Seismic Life-Safety, Modernization, and Replacement of General Purpose Buildings, Phase II, at LBNL (09-SC-72)	20,063	12,975	0
Technology and Engineering Development Facility at TJNAF (09-SC-74)	28,419	12,337	0
Total, Construction	119,116	104,922	109,571
Total, Science Laboratories Infrastructure	125,748	111,800	117,790

Public Law Authorizations

Public Law 95–91, "Department of Energy Organization Act", 1977
Public Law 109–58, "Energy Policy Act of 2005"
Public Law 110–69, "America COMPETES Act of 2007"
Public Law 111–358, "America COMPETES Act of 2010"

Program Overview and Benefits

The Science Laboratories Infrastructure (SLI) program mission is to support scientific and technological innovation at the Office of Science (SC) laboratories by funding and sustaining mission-ready infrastructure and fostering safe and environmentally responsible operations. The program provides the infrastructure necessary to support world leadership by the SC national laboratories in the area of basic scientific research now and in the future.

SLI's primary focus is on long-term modernization of SC laboratory infrastructure to ensure the mission readiness of SC Laboratories. Through this program, SC is ensuring that its laboratories have state-of-the-art facilities and utilities that are flexible, reliable, and sustainable, with environmentally stable research space and high performance computing space needed to support scientific discovery. Facility designs ensure safe, collaborative, and interactive work environments, allow for the integration of basic and applied research and development, and also aid in the recruitment and retention of world-class scientists to work at world-class laboratories. Projects, in many cases include funds for removal of aged and outdated facilities that are being replaced by new ones. New and renovated buildings and utilities include the latest temperature and humidity controls, clean power, and isolation from vibration and electromagnetic interference where needed. Other small facility decontamination and decommissioning and cleanup projects not included in the SLI construction program are funded with laboratory overhead. SLI currently has a portfolio of over 30 construction projects across all ten SC laboratories that will provide modernized, mission ready, infrastructure.

In addition to the construction program, SLI's Infrastructure Support program provides SC stewardship responsibilities for the Oak Ridge Reservation and the Federal facilities in the City of Oak Ridge, Tennessee, and Payments in Lieu of Taxes (PILT) to local communities around the Argonne, Brookhaven, and Oak Ridge National Laboratories. Beginning in FY 2013, SLI will provide funding to support facilities and infrastructure for the Office of Scientific and Technical Information (OSTI) at Oak Ridge and the New Brunswick Laboratory (NBL) at the Argonne Site. These activities were previously budgeted in SC Program Direction.

Program Accomplishments and Milestones

- *The Physical Sciences Facility (PSF) project at Pacific Northwest National Laboratory***.** In FY 2011, five new structures, as well as refurbishment of Building 325 were completed and accepted for occupancy under the PSF construction project at Pacific Northwest National Laboratory (PNNL). These facilities will allow better integration of basic scientific research with homeland and national security research. The FY 2011 DOE Federal Project Director of the Year Award was given to the Federal manager on this project.
- *The Modernization of Laboratory Facilities (MLF) at Oak Ridge National Laboratory (ORNL).* This project was accepted for occupancy on May 25, 2011 and received approval for project closeout on June 23, 2011, well ahead of the December 2011 baseline date. This replacement research facility provides fume hood-intensive wet chemistry laboratories and analytical instrumentation laboratories with clean electrical power to house ORNL's Chemical Sciences and Materials Science and Technology Divisions. With this new facility, ORNL can successfully carry out materials and chemistry research capabilities including catalysis, soft and bio-mimetic materials, advanced separation and mass spectrometry, chemical imaging and electron microscopy, geochemistry, nanomaterials and nanoscience, materials design and synthesis, chemical and structural materials theories, and condensed matter physics.
- *Demolition of Building 51 and Bevatron Demolition Project at Lawrence Berkeley National Laboratory*. The project is eliminating a legacy accelerator which ceased operation in 1993, freeing up approximately three acres of much needed land at the site for programmatic use. In FY 2011, the project demolished and disposed of the accelerator building (approximately 1,100 tons of steel) and characterized and disposed of approximately 14,000 cubic yards of concrete from the slab and foundations.

Milestone	Date
Complete construction on Building 74 of the Seismic Life-Safety, Modernization, and Replacement of General Purpose Buildings, Phase II project at LBNL.	4th Qtr. FY 2012
Approve start of construction for the balance of the Research Support Building project at SLAC	3rd Qtr. FY 2013
Approve alternative selection and cost range for the Science and User Support Building at SLAC	3rd Qtr. FY 2012

Explanation of Changes

The FY 2013 budget request funds the continuation of four ongoing construction projects, of which three projects are scheduled to receive final funding. The projects planned to be fully funded in FY 2013 are the Research Support Building and Infrastructure Modernization project at SLAC National Accelerator Laboratory (SLAC), the Energy Sciences Building at Argonne National Laboratory (ANL), and the Renovate Science Laboratories project at Brookhaven National Laboratory (BNL). The FY 2013 request provides second year funding for the Science and User Support Building project at SLAC National Accelerator Laboratory (SLAC). There are two new construction project starts included in the FY 2013 request: the Utilities Upgrade project at Fermi National Accelerator Laboratory (FNAL) and the Utility Infrastructure Modernization project at Thomas Jefferson National Accelerator Facility (TJNAF).

Infrastructure Support funding increases in the FY 2013 request to accommodate the transfer of funding for facilities and infrastructure support at the OSTI facility at Oak Ridge and the NBL facility at the Argonne Site that were previously budgeted through SC Program Direction.

Program Planning and Management

SLI's portfolio of infrastructure modernization construction projects has been established in full collaboration with the SC Deputy Director for Field Operations and the Deputy Director for Science Programs. SLI reviews the priorities for new construction projects each year in concert with the Director of Science and the Deputy Director for Science Programs in order to assure the project starts are consistent with future science mission priorities. SLI relies on the SC Annual Laboratory Plans for this annual review. These plans integrate scientific planning with infrastructure and operational planning by directly tying proposed investments to identified mission capability gaps. The plans provide a concise picture of the mission readiness of each laboratory, the capability gaps, and the investments necessary to fill those gaps. The investments proposed form the basis for projects included in the Initiative.

Projects included in the Initiative are rigorously managed in accordance with the requirements of DOE Order 413.3B, *Program and Project Management for the Acquisition of Capital Assets*, as well as Office of Science policies and procedures, including Independent Project Reviews. SLI program managers work closely with the SC Budget and Project Assessment offices during project planning and execution. As a result, performance of SLI projects under the Infrastructure Modernization Initiative has been on track with commitments. In FY 2011, 16 SLI Infrastructure Modernization Initiative projects received successful Lehman Reviews including progress reviews, 13 received CD approvals by the SC Acquisition Board, and all baseline milestones were met.

Program Goals and Funding

Revitalizing facilities and providing modern laboratory infrastructure is critical to ensuring the continued mission readiness of SC laboratories. Mission readiness of a laboratory's facilities and infrastructure is the capability of those assets to effectively support the scientific mission assigned to the laboratory. The current and future mission readiness of each SC laboratory is evaluated using a peer review process which focuses on the ability of each laboratory infrastructure element to meet the needs of scientific research. The Infrastructure Modernization Initiative will provide capital investment through the SLI program to make these needed improvements. The goals of the Infrastructure Modernization Initiative are to provide the modern laboratory infrastructure needed to deliver advances in science the Nation requires to remain competitive in the 21st century and to correct longstanding deficiencies while ensuring laboratory infrastructure provides a safe and quality workplace.

Goal Areas by Subprogram

	Research	Facility Operations	Future Facilities	Workforce
Infrastructure Support	0%	0%	100%	0%
Line Item Construction	0%	0%	100%	0%
Total, Science Laboratories Infrastructure	0%	0%	100%	0%

Explanation of Funding and Program Changes

	(Dollars in Thousands)		
	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Infrastructure Support	6,878	8,219	+1,341
In FY 2013, the increase supports the initiation of funding for facilities and infrastructure at the OSTI facility at Oak Ridge and the NBL facility at the Argonne Site that were previously budgeted through SC Program Direction and increased support for Oak Ridge Landlord.			
Line Item Construction	104,922	109,571	+4,649
The FY 2013 request supports the continuation of four ongoing projects and the start of two new projects.			
Total, Science Laboratories Infrastructure	111,800	117,790	+5,990

Infrastructure Support
Funding Profile by Activity

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Oak Ridge Landlord	5,250	5,493	5,934
Payments in Lieu of Taxes	1,382	1,385	1,385
Facilities and Infrastructure	0	0	900
Total, Infrastructure Support	6,632	6,878	8,219

Overview

The Infrastructure Support subprogram provides SC stewardship responsibilities for the Oak Ridge Reservation and DOE facilities and Office of Scientific and Technical Information (OSTI) in the city of Oak Ridge, Tennessee and facilities infrastructure support for New Brunswick Laboratory (NBL) at the Argonne site.

Infrastructure Support also provides Payments in Lieu of Taxes (PILT) to local communities around the Argonne, Brookhaven, and Oak Ridge National Laboratories. Beginning in FY 2013, SLI will provide funding to support facilities and infrastructure for the Federal facilities that house OSTI at Oak Ridge and NBL at the Argonne site; these activities were previously budgeted in SC Program Direction.

Explanation of Funding Changes

	(Dollars in Thousands)		
	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Oak Ridge Landlord	5,493	5,934	+441
Funding increases to accommodate the transfer of funding for facilities and infrastructure at the OSTI facility. This funding was previously budgeted through SC Program Direction. The increase also supports reservation road repairs and other critical maintenance needs at the Oak Ridge Reservation and other DOE facilities in Oak Ridge.			
Payments in Lieu of Taxes	1,385	1,385	0
Funding is maintained at the current level.			
Facilities and Infrastructure	0	900	+900
Funding increases to accommodate the transfer of funding for facilities and infrastructure at NBL. This funding was previously budgeted through SC Program Direction.			
Total, Infrastructure Support	6,878	8,219	+1,341

Oak Ridge Landlord

Overview

Funding supports landlord responsibilities, including infrastructure for the 24,000 acre Oak Ridge Reservation, OSTI, and DOE facilities in the city of Oak Ridge, Tennessee. Activities include maintenance of roads, grounds, and other infrastructure; support and improvement of environmental protection, safety, and health; routine infrastructure maintenance at OSTI; and Payment in Lieu of Taxes (PILT) to Oak Ridge communities. Landlord responsibilities exclude the Y-12 plant, ORNL, and the East Tennessee Technology Park.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	Funding provided for activities to ensure continuity of operations and minimize interruptions due to infrastructure or other system failures.	5,250
2012 Enacted	Funding provided for activities to ensure continuity of operations and minimize interruptions due to infrastructure or other system failures.	5,493
2013 Request	Funding in FY 2013 is requested for support of Oak Ridge Reservation landlord responsibilities and to initiate support of OSTI facility and infrastructure expenses.	5,934

Payments in Lieu of Taxes

Overview

The Department is authorized to provide discretionary payments to State and local government authorities for real property that is not subject to taxation because it is owned by the United States and operated by the Department. Under this authorization, PILT is provided to communities around the Argonne and Brookhaven National Laboratories to compensate for lost tax revenues for land removed from local tax rolls. PILT payments are negotiated between the Department and local governments based on land values and tax rates.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	Funding provided for discretionary payments to communities around the Argonne and Brookhaven National Laboratories.	1,382
2012 Enacted	Funding supports the Department's authorization to provide PILT payments to communities around Argonne and Brookhaven National Laboratories.	1,385
2013 Request	Funding will continue to support the Department's authorization to provide PILT payments to communities around the Argonne and Brookhaven National Laboratories.	1,385

Facilities and Infrastructure

Overview

Funding within this activity is provided for maintenance of general purpose infrastructure at the New Brunswick Laboratory (NBL), located on the site of the Argonne National Laboratory (ANL).

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	In FY 2011, these activities were funded by SC program direction.	0
2012 Enacted	In FY 2012, these activities were funded by SC program direction.	0
2013 Request	Funding provided to initiate support of NBL facilities and infrastructure.	900

Construction
Funding Profile by Activity

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Construction			
Utilities Upgrade at FNAL (13-SC-70)	0	0	2,500
Utility Infrastructure Modernization at TJNAF (13-SC-71)	0	0	2,500
Science and User Support Building at SLAC (12-SC-70)	0	12,086	21,629
Research Support Building and Infrastructure Modernization at SLAC (10-SC-70)	40,694	12,024	36,382
Energy Sciences Building at ANL (10-SC-71)	14,970	40,000	32,030
Renovate Science Laboratories, Phase II, at BNL (10-SC-72)	14,970	15,500	14,530
Seismic Life-Safety, Modernization, and Replacement of General Purpose Buildings, Phase II, at LBNL (09-SC-72)	20,063	12,975	0
Technology and Engineering Development Facility at TJNAF (09-SC-74)	28,419	12,337	0
Total, Construction	119,116	104,922	109,571

Overview

The SLI Construction subprogram funds line item construction projects to maintain and enhance the general purpose infrastructure at SC laboratories. Infrastructure Modernization Initiative investments are funded in this subprogram and are focused on the accomplishment of long-term science goals and strategies at each SC laboratory. Projects are selected using a collaborative approach involving SC Site Office Managers, laboratory Chief Operating Officers, the SC Deputy Directors for Field Operations and Science Programs, and the SC research program Associate Directors.

Explanation of Funding Changes

	(Dollars in Thousands)		
	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Utilities Upgrade at FNAL (13-SC-70)	0	2,500	+2,500

FNAL currently has design concepts established for a group of neutrino projects, including the Muon to Electron Conversion Experiment (Mu2e) funded through the High Energy Physics (HEP) program. The reliability of the current industrial cooling water and high-voltage electrical distribution systems is suffering due to increased pipe break and electrical failures. Also, current and future accelerator and experimental facilities at FNAL will exhaust the capacity of the existing utility systems. Additional stresses to the system will exacerbate these problems. The proposed Utilities Upgrade project will upgrade the laboratory's industrial cooling water and high voltage electrical system, which will mitigate environmental liability, improve reliability, and allow FNAL to effectively perform high energy physics research. Project engineering and design activities are initiated in FY 2013.

	(Dollars in Thousands)		
	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Utilities Improvement Project at TJNAF (13-SC-71)	0	2,500	+2,500

TJNAF's accelerator science core capability has an immediate need for investments to ensure the laboratory utilities infrastructure can continue to support the superconducting radio frequency mission in the research, development, and production of cryomodules. Existing utility systems continue to experience failures at increasing rates, which limits the laboratory's ability to perform a complementary role within SC research programs. The most critical shortfall is the inability to use an alternative power feed to restart the Central Helium Liquefier, which is a critical component to maintaining constant cryogenic temperatures in the accelerator cryomodules that prevent degradation of accelerator performance and costly repairs. This reduces reliability of accelerator performance which could impact research performed by the Nuclear Physics (NP) and HEP programs. The proposed Utilities Improvement Project will increase capacity to the cryogenic, electrical power distribution, cooling water, and communication systems and will improve performance and reliability while supporting SC research programs. Project Engineering and Design and preliminary construction activities are initiated in FY 2013.

Science and User Support Building at SLAC (12-SC-70)	12,086	21,629	+9,543

SLAC's Linac Coherent Light Source (LCLS) and Stanford Synchrotron Radiation Light Source (SSRL), through a common user support office, engage, train, and support a new generation of scientific users with a range of disciplines in physical sciences, engineering, and medicine whose skills bridge x-ray and laser physics capabilities. With the success of the LCLS, SLAC is benefiting from a large influx of visitors and users and expects the demand to use SLAC's research facilities will continue to grow. To ensure that world-class research conducted is supported by mission-ready facilities, an expansion of user space is needed. SLI's Science and User Support building project will serve as the main entrance to the laboratory—the first stop for all visitors and users at SLAC, and will bring together many of the laboratory's visitors, users, and administrative services. This will enhance scientific productivity and collaboration that supports the laboratory's cutting-edge discoveries and exceptional user research program. Increased funding supports the continuation of construction activities per the planned profile in the Preliminary Project Execution Plan.

	(Dollars in Thousands)		
	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Research Support Building and Infrastructure Modernization at SLAC (10-SC-70)	12,024	36,382	+24,358

SLAC has evolved from a single program to a multi-program laboratory. This transition, combined with the condition and age of SLAC facilities, drives the need to consolidate core research groups and modernize key support buildings. The Research Support Building and Infrastructure Modernization project will improve accelerator research capabilities and efficiency by collocating Particle Physics, SSRL, and LCLS functions. Additionally, the Accelerator Main Control Center, which will be located within the Research Support Building, will contribute to the co-location of accelerator scientists and strengthen ties and interactions between control room operators and related areas of research and support functions as well as provide them a stronger connection to the main campus. Funding supports the continuation of construction activities per the planned profile in the Project Execution Plan.

Energy Sciences Building at ANL (10-SC-71)	40,000	32,030	-7,970

ANL's core research capabilities are currently hampered by antiquated, scientifically inadequate, and inefficient research space as the original site plan was designed when science research was done as a set of separate disciplines. The Energy Science Building project will replace some of the oldest and least effective research space with new, environmentally stable, and specialized multi-disciplinary laboratory space. This integration will enable multi-functionality and enhance capabilities of research funded through the Basic Energy Science (BES) program including biomolecules; superconductors and magnets; catalysts with intricately structured surfaces; and hybrid solar cells integrating nanoscale dyes, semiconductors, and electrolytes. Funding supports the continuation of construction activities per the planned profile in the Project Execution Plan.

Renovate Science Laboratories, Phase II, at BNL (10-SC-72)	15,500	14,530	-970

This project provides upgrades to several laboratory buildings at BNL. Building 510 (the Physics Department) is essential to research supported by NP and HEP as it is home to scientists from the PHENIX and STAR collaborations at the Relativistic Heavy Ion Collider (RHIC) facility and is the center for the U.S. ATLAS group that works at the Large Hadron Collider at CERN. This building also accommodates research related to the MINOS experiment at Fermilab, and the Long Baseline Neutrino Experiment. Building 510 (the Chemistry Department) is essential to research supported by the BES program as it is the primary site for wet chemistry and is linked to BNL's Center for Functional Nanomaterials, the National Synchrotron Light Source (NSLS), and the future NSLS-II. The Renovate Science Labs, Phase II project will improve the working environment of scientists by modernizing the laboratory space in these two buildings which will boost operational efficiency, save energy through more efficient buildings, and provide facilities that meet ES&H codes to improve safety. Funding supports the continuation of construction activities per the planned profile in the Project

	(Dollars in Thousands)		
	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Execution Plan.			
Seismic Life-Safety, Modernization, and Replacement of General Purpose Buildings, Phase II, at LBNL (09-SC-72)	12,975	0	-12,975
This project will remedy high seismic life-safety risks by replacing seismically-poor buildings and trailers with a new general purpose laboratory/office building, upgrading the Waste Handling Facility, and modernizing an existing Life Sciences Building. This project received final funding in FY 2012 and is planned for project closeout in FY 2015.			
Technology and Engineering Development Facility at TJNAF (09-SC-74)	12,337	0	-12,337
This project will renovate existing space and construct new space in the Test Lab Building, to provide efficient workflow, a safe and sustainable work environment, and functional efficiencies. This project received final funding in FY 2012 and is expected to receive approval for project closeout in FY 2014.			
Total, Construction	104,922	109,571	+4,649

Supporting Information

Operating Expenses, Capital Equipment, and Construction Summary

(Dollars in Thousands)

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Operating Expenses	6,532	6,778	8,119
General Plant Projects	100	100	100
Construction	119,116	104,922	109,571
Total, Science Laboratories Infrastructure	125,748	111,800	117,790

Construction Projects

(Dollars in Thousands)

	Prior Years	FY 2011 Current	FY 2012 Enacted	FY 2013 Request	Outyears	Total
Utilities Upgrade at FNAL (13-SC-70)						
TEC	0	0	0	2,500	32,400	34,900
OPC[a]	390	710	0	0	0	1,100
TPC	390	710	0	2,500	32,400	36,000[b]
Utility Infrastructure Modernization at TJNAF (13-SC-71)						
TEC	0	0	0	2,500	26,700	29,200
OPC[a]	400	300	0	0	0	700
TPC	400	300	0	2,500	26,700	29,900[c]
Science & User Support Building at SLAC (12-SC-70)						
TEC	0	0	12,086	21,629	30,285	64,000
OPC[a]	0	500	0	0	500	1,000
TPC	0	500	12,086	21,629	30,785	65,000[d]

[a] Other Project Costs shown are funded through laboratory overhead.

[b] This project has not yet received CD-2 approval; funding estimates are consistent with the high end of the preliminary cost ranges. The preliminary TEC range for this project is $31,300,000 to $34,900,000. The preliminary TPC range for this project is $32,400,000 to $36,000,000.

[c] This project has not yet received CD-2 approval; funding estimates are consistent with the high end of the preliminary cost ranges. The preliminary TEC range for this project is $24,300,000 to $29,200,000. The preliminary TPC range for this project is $25,000,000 to $29,900,000.

[d] This project has not yet received CD-2 approval; funding estimates are consistent with the high end of the preliminary cost ranges. The preliminary TEC range for this project is $59,000,000 to $64,000,000. The preliminary TPC range for this project is $60,000,000 to $65,000,000.

(Dollars in Thousands)

	Prior Years	FY 2011 Current	FY 2012 Enacted	FY 2013 Request	Outyears	Total
Research Support Building and Infrastructure Modernization at SLAC (10-SC-70)						
TEC	6,900	40,694	12,024	36,382	0	96,000
OPC[a]	700	5	215	250	230	1,400
TPC	7,600	40,699	12,239	36,632	230	97,400
Energy Sciences Building at ANL (10-SC-71)						
TEC	8,000	14,970	40,000	32,030	0	95,000
OPC[a]	956	0	0	0	0	956
TPC	8,956	14,970	40,000	32,030	0	95,956
Renovate Science Laboratories, Phase II, at BNL (10-SC-72)						
TEC	5,000	14,970	15,500	14,530	0	50,000
OPC[a]	737	63	0	0	0	800
TPC	5,737	15,033	15,500	14,530	0	50,800
Seismic Life-Safety, Modernization, and Replacement of General Purpose Buildings, Phase II, at LBNL (09-SC-72)						
TEC	61,522	20,063	12,975	0	0	94,560
OPC[a]	2,256	0	74	150	0	2,480
TPC	63,778	20,063	13,049	150	0	97,040
Technology and Engineering Development Facility at TJNAF (09-SC-74)						
TEC	31,387	28,419	12,337	0	0	72,143
OPC[a]	1,000	0	0	0	0	1,000
TPC	32,387	28,419	12,337	0	0	73,143
Total, Construction						
TEC		119,116	104,922	109,571		
OPC[a]		1,578	289	400		
TPC		120,694	105,211	109,971		

[a] Other Project Costs shown are funded through laboratory overhead.

Indirect Costs and Other Items of Interest for the Office of Science

General Plant Projects

General Plant Projects (GPPs) are construction projects that are less than $10 million and necessary to adapt facilities to new or improved production techniques, to effect economies of operation, and to reduce or eliminate health, fire, and security problems. The following table displays total GPP funding across the Office of Science by site.

	(Dollars In Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Ames Laboratory	2,110	200	2,315
Argonne National Laboratory	0	0	1,000
Lawrence Berkeley National Laboratory	0	0	1,000
Oak Ridge National Laboratory	2,375	0	2,000
Sandia National Laboratories	4,110	0	0
SLAC National Accelerator Laboratory	3,640	0	1,000
Fermi National Accelerator Laboratory	3,177	8,675	14,900
Notre Dame, University	395	0	0
Oak Ridge Institute for Science and Education	700	500	500
Oak Ridge Office	100	100	100
Pacific Northwest National Laboratory	2,125	400	0
Princeton Plasma Physics Laboratory	1,653	465	465
Thomas Jefferson National Acceleratory Facility	2,516	2,000	2,000
Total, GPP	22,901	12,340	25,280

Institutional General Plant Projects

Institutional General Plant Projects (IGPPs) are construction projects that are less than $10 million and cannot be allocated to a specific program. IGPPs fulfill multi-programmatic and/or inter-disciplinary needs and are funded through site overhead. The following table displays total IGPP funding across all SC laboratories by site.

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Argonne National Laboratory	14,379	10,056	15,180
Brookhaven National Laboratory	7,304	10,000	10,000
Fermi National Accelerator Laboratory	1,809	0	0
Lawrence Berkeley National Laboratory	5,585	5,500	6,000
Oak Ridge National Laboratory	25,613	15,000	15,000
Pacific Northwest National Laboratory	2,731	14,700	13,600
SLAC National Accelerator Laboratory	516	3,810	4,091
Total IGPP	57,937	59,066	63,871

Facilities Maintenance and Repair

General purpose infrastructure includes multiprogram research laboratories, administrative and support buildings, as well as cafeterias, power plants, fire stations, utilities, roads, and other structures. Together, the SC laboratories have over 1,400 operational buildings and real property trailers, with nearly 20 million gross square feet of space. The Department's facilities maintenance and repair activities are tied to its programmatic missions, goals, and objectives. Facilities Maintenance and Repair activities funded at SC laboratories are displayed in the following tables.

Indirect-Funded Maintenance and Repair

Facilities maintenance and repair activities funded indirectly through overhead charges at SC laboratories are displayed below. Since this funding is allocated to all work done at each laboratory, the cost of these activities is allocated to SC and other DOE organizations, as well as other Federal agencies and other entities doing work at SC laboratories. Maintenance reported to SC for non-SC laboratories is also shown. The figures below are total projected expenditures across all SC laboratories.

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Ames Laboratory	1,166	1,147	1,192
Argonne National Laboratory	44,158	50,755	51,951
Brookhaven National Laboratory	36,896	36,742	38,272
Fermi National Accelerator Laboratory	15,162	16,178	16,773
Lawrence Berkeley National Laboratory	21,057	17,200	17,500
Lawrence Livermore National Laboratory	2,666	2,719	2,773
Los Alamos National Laboratory	115	117	119
Oak Ridge Institute for Science and Education	858	413	403
Oak Ridge National Laboratory	56,320	58,712	60,062
Oak Ridge National Laboratory facilities at Y-12	1,073	602	615
Pacific Northwest National Laboratory	4,221	4,300	3,797
Princeton Plasma Physics Laboratory	6,695	6,045	6,786
Sandia National Laboratories	2,499	2,548	2,598
SLAC National Accelerator Laboratory	10,405	17,424	16,954
Thomas Jefferson National Accelerator Facility	5,139	4,450	5,200
Total, Indirect-Funded Maintenance and Repair	208,430	219,352	224,995

Direct-Funded Maintenance and Repair

Generally, facilities maintenance and repair expenses are funded through an indirect overhead charge. In some cases, however, a laboratory may charge maintenance directly to a specific program. One example would be when maintenance is performed in a building used only by a single program. Such direct-funded charges are not directly budgeted.

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Brookhaven National Laboratory	6,870	5,696	5,843
Fermilab National Accelerator Facility	126	122	127
Notre Dame Radiation Laboratory	173	171	173
Oak Ridge National Laboratory	15,183	15,388	15,742
Oak Ridge Office	5,071	5,100	8,172
Office of Scientific and Technical Information	346	355	364
SLAC National Accelerator Laboratory	2,789	838	1,220
Thomas Jefferson National Accelerator Facility	77	63	65
Total, Direct-Funded Maintenance and Repair	30,635	27,733	31,706

13-SC-70, Utilities Upgrade, Fermi National Accelerator Laboratory (FNAL), Batavia, Illinois
Project Data Sheet is for PED

1. Significant Changes

The most recent DOE O 413.3B approved Critical Decision (CD) is CD-1, *Approve Alternative Selection and Cost Range*, which was approved on November 15, 2010. The preliminary Total Estimated Cost (TEC) range for this project is $31,300,000 to $34,900,000. The preliminary Total Project Cost (TPC) range for this project is $32,400,000 to $36,000,000.

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

This Project Data Sheet (PDS) is new and does include a new start for the budget year.

2. Design, Construction, and D&D Schedule

(Fiscal Quarter To Date)

	CD-0	CD-1	PED Complete	CD-2	CD-3	CD-4
FY 2013	9/18/2009	11/15/2010	1Q FY 2014	4Q FY 2013[a]	3Q FY 2014[a]	3Q FY 2015[a]

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

3. Baseline and Validation Status

(Dollars in Thousands)

	TEC, PED	TEC, Construction	TEC, Total	OPC[b] Except D&D	OPC,D&D	OPC, Total	TPC
FY 2013	4,450	30,450[c]	34,900[c]	1,100	0	1,100	36,000[c]

4. Project Description, Justification, and Scope

Mission Need

DOE is a leading sponsor of research in particle physics and FNAL remains focused on particle physics while progressing research efforts to neutrino physics at the intensity frontier. Existing facilities are subjected to decreased reliability as pipe breaks and electrical equipment failures become more common. FNAL also currently has design concepts established for a group of neutrino projects including the Muon to Electron Conversion Experiment (Mu2e) funded through the SC High Energy Physics (HEP) program. These and future accelerator and experimental facilities at FNAL will exhaust the capabilities of the existing utility systems in capacity

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[a] This project is pre-CD-2 and schedule estimates are preliminary.
[b] Other project costs (OPC) are funded through laboratory overhead.
[c] This project has not yet received CD-2 approval; funding estimates are consistent with the high end of the preliminary cost ranges. The preliminary TEC range for this project is $31,300,000 to $34,900,000. The preliminary TPC range for this project is $32,400,000 to $36,000,000.

Scope and Justification (13-SC-70, Utilities Upgrade at FNAL)

Maintaining a dependable research infrastructure from which science programs can be accomplished is dependent on robust, redundant, maintainable, and flexible utility systems. The backbone of Fermilab's utility systems is its industrial cooling water (ICW) and high voltage electrical systems. Without these systems, science at Fermilab cannot exist. This project, originally included in the FY 2011 Budget Request, will upgrade both of these systems and significantly extend their useful lifespans.

The ICW system consists of ponds, pumping stations, and approximately 72,000 feet of underground network piping, supplying process cooling and fire protection water throughout the laboratory's 6,800 acre site. As most of the system was installed during the construction of the lab, almost 40 years ago most components of the system have reached the end of their useful life. The fragile state of the piping and valves currently in service, reduction in flows by biofouling, and frequent pipe failures jeopardize the reliability and maintainability of the ICW system. The current system requires frequent and unscheduled repairs which are complicated by insufficient and often malfunctioning isolation valves, enlarging the disabled area being repaired. Reliable process cooling and fire protection water service cannot be provided to current accelerator and experimental facilities areas as well as those areas slated for development of future facilities unless substantial re-investment in the lab's ICW system is provided. The new system will include state of the art materials to mitigate the existing conditions such as biofouling (zebra mussels) and valves to properly isolate various locations of the system. These improvements will significantly extend the useful life of the system.

The high voltage electrical system consists of substations, switches, and transformers. Various elements of the high voltage distribution system are rated as poor based on their current condition, are unreliable, and will continue to deteriorate with age. Future science at Fermilab is dependent upon a robust, redundant, maintainable, and flexible high voltage electrical distribution system for both programmatic and conventional power needs. The master substation and numerous oil switches and transformers across the site were installed during the original construction of the laboratory in the early 1970s. Much of this equipment is now beyond its useful life, and substantial reinvestment in this system is required for continued science in support of the Fermilab mission. This project will mitigate environmental liability (e.g. oil switches replaced with air switches), improve reliability, and allow FNAL to effectively perform high energy physics research. Furthermore, this project will upgrade and expand these utilities to provide a flexible base to serve existing facilities and provide the backbone from which future projects will build to serve new facilities. Many parts of the system are no longer manufactured; therefore, they cannot be maintained nor replaced in kind. New state of the art transformers and substations will be provided to extend system life. This will establish a stable base from which to serve both programmatic and conventional requirements across the site.

Key Performance Parameters

Description	Threshold Value (Minimum)	Objective Value (Maximum)
High-Voltage Electrical (H/V) Upgrade	Perform all Distribution System Modifications required to isolate Master Substation Replace all oil switches with new air switches Replace 7 unit substations	Threshold value plus: Replace feeder cable > 25 years old Replace all end-of-life unit substations Perform all Master Substation Modifications to improve system reliability, including replacing the control wiring and upgraded metering, upgrading the 345kV oil circuit breaker, and performing various yard modifications

Description	Threshold Value (Minimum)	Objective Value (Maximum)
Industrial Cooling Water (ICW) Upgrade	Install new backbone piping network from Casey's Pond to the Main Ring ICW system	Threshold value plus: Install new Backfeed Loop System to improve reliability and to provide greater sectionalization of the ICW system, including installing new ICW transmission mains, upgrading primary and secondary pumphouses, and automating transfer of stored water in east ponds into the ICW system

Other Project Costs, funded through laboratory overhead, were used to complete the conceptual design. FY 2013 PED funds will be used for preliminary design and include associated project management and support costs.

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[a]			
FY 2013	2,500	2,500	2,500
FY 2014	1,950	1,950	1,950
Total, PED	4,450	4,450	4,450
Construction			
FY 2013	0	0	0
FY 2014	30,450	30,450	23,524
FY 2015	0	0	6,926
Total, Construction	30,450[b]	30,450[b]	30,450[b]

[a] All design will be completed in less than 18 months.

[b] This project has not yet received approval of CD-2; funding estimates are consistent with the high end of the preliminary cost ranges. The preliminary TEC range is $31,300,000 to $34,900,000. The preliminary TPC range is $32,400,000 to $36,000,000.

(Dollars in Thousands)

	Appropriations	Obligations	Costs
TEC			
FY 2013	2,500	2,500	2,500
FY 2014	32,400	32,400	25,474
FY 2015	0	0	6,926
Total, TEC	34,900[b]	34,900[b]	34,900[b]
Other Project Cost (OPC)[a]			
OPC except D&D			
FY 2010	390	390	390
FY 2011	710	710	710
Total, OPC	1,100	1,100	1,100
Total Project Cost (TPC)			
FY 2010	390	390	390
FY 2011	710	710	710
FY 2012	0	0	0
FY 2013	2,500	2,500	2,500
FY 2014	32,400	32,400	25,474
FY 2015	0	0	6,926
Total, TPC[b]	36,000[a]	36,000[a]	36,000[a]

[a] Other Project Costs are funded through laboratory overhead.
[b] This project has not received approval of CD-2; funding estimates are consistent with the high end of the preliminary cost ranges. The preliminary TEC range for this project is $31,300,000 to $34,900,000. The preliminary TPC range for this project is $32,400,000 to $36,000,000.

6. Details of Project Cost Estimate

(Dollars in Thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design (PED)[a]			
Design	3,560	N/A	N/A
Contingency	890	N/A	N/A
Total, PED	4,450	N/A	N/A
Construction			
Construction	24,360	N/A	N/A
Contingency	6,090	N/A	N/A
Total, Construction	30,450[a]	N/A	N/A
Total, TEC	27,920[a]	N/A	N/A
Contingency, TEC	6,980	N/A	N/A
Other Project Cost (OPC)[b]			
OPC except D&D			
Conceptual Planning	500	N/A	N/A
Conceptual Design	400	N/A	N/A
Contingency	200	N/A	N/A
Total, OPC	1,100	N/A	N/A
Contingency, OPC	200	N/A	N/A
Total, TPC[b]	28,820[b]	N/A	N/A
Total, Contingency	7,180	N/A	N/A

[a] All design will be completed in less than 18 months.
[b] Other Project Costs are funded through laboratory overhead.

7. Funding Profile History

Request Year		(Dollars in Thousands) FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	Total
FY 2013	TEC	0	0	0	2,500	32,400	0	0	0	34,900[a]
	OPC[a]	390	710	0	0	0	0	0	0	1,100
	TPC	390	710	0	2,500	32,400	0	0	0	36,000[b]

8. Related Operations and Maintenance Funding Requirements

Not applicable.

9. Required D&D Information

Not applicable.

10. Acquisition Approach

Not applicable.

[a] This project has not yet received approval of CD-2; funding estimates are consistent with the high end of the preliminary cost ranges. The preliminary TEC range for this project is 31,300,000 to $34,900,000. The preliminary TPC range for this project is $32,400,000 to $36,000,000.

13-SC-71, Utility Infrastructure Modernization,
Thomas Jefferson National Accelerator Facility (TJNAF), Newport News, Virginia
Project Data Sheet is for PED/Construction

1. Significant Changes

The most recent DOE O 413.3B approved Critical Decision (CD) is CD-1, *Approve Alternative Selection and Cost Range*, which was approved October 14, 2010. The preliminary Total Estimated Cost (TEC) range for this project is $24,300,000 to $29,200,000. The preliminary Total Project Cost (TPC) range for this project is $25,000,000 to $29,900,000.

A Federal Project Director at the appropriate level has been assigned to this project.

This Project Data Sheet (PDS) is new and does include a new start for the budget year.

2. Design, Construction, and D&D Schedule

(Fiscal Quarter or Date)

	CD-0	CD-1	PED Complete	CD-2	CD-3	CD-4
FY 2013[a]	9/18/2009	10/14/2010	4Q FY 2013	4Q FY 2013[a]	4Q FY 2013[a]	4Q FY 2015[a]

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

3. Baseline and Validation Status

(Dollars in Thousands)

	TEC, PED	TEC, Construction	TEC, Total	OPC[b] Except D&D	OPC, D&D	OPC, Total	TPC
FY 2013	900	28,300[c]	29,200[c]	700	0	700	29,900[c]

4. Project Description, Justification, and Scope

Mission Need

DOE is an important sponsor of research in nuclear physics and TJNAF maintains a central and unique role in the field of nuclear physics as a world leader in hadronic physics and superconducting accelerator technologies. At TJNAF, the accelerator science core capability has an immediate need for investment to ensure the laboratory utilities infrastructure can continue to support the superconducting radio frequency (SRF) mission in the research, development, and production of cryomodules. Existing utility, cryogenic, power distribution, cooling water, and communication systems at TNJAF continue to experience failures at increasing rates, which limits the laboratory's ability to support SC research programs. For example, the current cryogenic capacity is inadequate to support the needs in the Test Lab, which is the key facility for SRF

[a] This project is pre-CD-2 and schedule estimates are preliminary. Construction funds will not be executed without appropriate CD approvals.
[b] Other Project Costs are funded through laboratory overhead.
[c] This project has not yet received CD-2 approval; funding estimates are consistent with the high end of the preliminary cost ranges. The preliminary TEC range for this project is $24,300,000 to $29,200,000. The preliminary TPC range for this project is $25,000,000 to $29,900,000.

development and production activities. This limits various SRF activities and research supported by the Nuclear Physics (NP) and High Energy Physics (HEP) programs. In addition, the current power distribution system does not have the necessary redundancy to maintain operation of critical systems during power outages. The most critical shortfall is the inability to use an alternative power feed to restart the Central Helium Liquefier (CHL), a critical component to maintaining constant cryogenic temperatures in the accelerator cryomodules that prevent degradation of accelerator performance and costly repairs. These inadequacies reduce reliability and could jeopardize the laboratory's capability to support ongoing research performed by NP and HEP.

Scope and Justification (13-SC-71, Utility Infrastructure Modernization at TJNAF)

The TJNAF cryogenic, power distribution, cooling water, and communication systems are experiencing failure at increasing frequencies and have insufficient capacity to meet current and forecasted need. This project is needed to address performance gaps in respect to providing a work environment that meets safety goals, current code standards and operational efficiency goals.

The Utilities Infrastructure Modernization (UIM) Project, originally included in the FY 2011 Budget Request, will upgrade the electrical distribution, process cooling, cryogenics, and communications systems at TJNAF by replacing aging infrastructure and providing needed additional capability. The scope of the project includes replacement of accelerator site primary and secondary electrical distribution feeders, thereby increasing the capacity for the electrical transfer feeder between the two on-site utility substations; replacement of 8–12 cooling tower cells to significantly extend the useful expected life of the process cooling system, expansion of the Cryogenics Test Facility with additional cryogenics equipment, and an expandable communications pathway for a fiber ring around the campus.

The cryogenic, power distribution, cooling water, and communication systems are 20–40 years old, dating back to the previous owner. The cryogenic system has insufficient capacity and, despite gains over the past several years on significantly improving the efficiency of major system components, there remains a need for overall system efficiency optimization. The lack of adequate cryogenic capacity is a limiting factor on scheduling SRF activities. The sizing of the systems to mitigate the effects of the limiting factors will be fully integrated during the final design process. Cryogenic system operation at TJNAF accounts for over 90% of annual electricity costs. Therefore, efficiency gains in this system will significantly contribute to a reduction in overall operating costs. Electricity energy savings from an upgrade to the Cryogenic Test Facility, a key component in the cryogenic system, are estimated to be 36%. The power distribution system capacity is currently taxed to its limit and will not support future projected needs. Electric feeders are at the end of their service life and are near failing. Insulation cracks have been observed on multiple feeders. Recent interruptions to accelerator operation due to failed components of the electrical supply heighten this concern.

The cooling water distribution system is suffering frequent failures and has insufficient capacity to support optimal experimental program scheduling, computer center heat loads, and future expected growth. Since 2008, failures of the cooling water distribution system have caused several weeks of down time for the Free Electron Laser facility. Cooling towers are well past their efficient life-cycle utilization and are requiring ever increasing amounts of maintenance. In addition, addressing this gap would achieve an estimated 10% energy savings.

Subsurface communications systems are outdated and unreliable. Because some of these systems are over 40 years old, replacement components are often unavailable. Phone switch parts are difficult to locate and no additional cabling capacity is available for telecommunications or data lines. Inadequate capacity is impacting the ability to install communications to support staff growth and replace degraded cables as necessary. These systems have reached the end of their life cycle. Consequently, instances of phone outages are impacting the efficiency of operations. The underground copper wiring is also past its service life. In addition, installation of an Emergency Broadcast System is necessary to meet safety goals and improve response efficiency. In order to meet the growth in communication requirements, both in size and type, new upgraded cabling will be necessary.

The proposed solutions under this project to address the utility system performance gaps at TJNAF are relatively straight-forward and include upgrades and expansion of cryogenic, electrical power distribution, cooling water, and communication systems. A detailed alternatives analysis using life-cycle costs will be conducted prior to CD-1.

Key Performance Parameters

Description	Threshold Value (Minimum)	Objective Value (Maximum)
Electrical Distribution System	Replace accelerator primary and secondary feeders with copper (upgrade from aluminum to copper)	Threshold value plus: Increase size of the tie line between substations
Process Cooling	Replace and extend system life of existing cooling towers at North and South Access plus Central Helium Liquefier Buildings Construct a 2,500 SF addition to the TEDF chiller plant building and a 800 ton chiller for the computer center	Threshold value plus: Replace the ESR cooling tower (life extension) Replace Building 92 cooling tower (life extension) Add a 1 MW UPS system for the computer center
Cryogenics Test Facility	1,000 square foot addition	2,500 square foot addition Upgrade cryogenic piping and support systems
Communications System Upgrade	Create an expandable pathway for a fiber ring around the campus to eliminate single points of failure for this core ring.	Threshold value plus: Establish redundant network path for major facilities. Establish 2 demarcation communication utility facilities from off-site (2,000 square foot)

Other Project Costs, funded through laboratory overhead, were used to complete the conceptual design in preparation for CD–1. FY 2013 PED funds will be used to complete preliminary and final designs for all aspects of the project. FY 2013 construction funds will be used for procurement of long-lead items and to start construction work as well as for project management and support activities

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[a]			
FY 2013	900	900	900
Total PED	900	900	900

[a] All design will be complete in less than 18 months

(Dollars in Thousands)

	Appropriations	Obligations	Costs
Construction			
FY 2013	1,600	1,600	1,600
FY 2014	26,700	26,700	10,700
FY 2015	0	0	16,000
Total, Construction	28,300[a]	28,300[a]	28,300[a]
TEC			
FY 2013	2,500	2,500	2,500
FY 2014	26,700	26,700	10,700
FY 2015	0	0	16,000
Total, TEC	29,200[a]	29,200[a]	29,200[a]
Other Project Cost (OPC)[b]			
OPC except D&D			
FY 2010	400	400	400
FY 2011	300	300	300
Total OPC	700	700	700
Total Project Cost (TPC)			
FY 2010	400	400	400
FY 2011	300	300	300
FY 2012	0	0	0
FY 2013	2,500	2,500	2,500
FY 2014	26,700	26,700	10,700
FY 2015	0	0	16,000
Total, TPC[a]	29,900[a]	29,900[a]	29,900[a]

[a] This project has not yet received CD-2 approval; funding estimates are consistent with the high end of the preliminary cost ranges. The preliminary TEC range for this project is $24,300,000 to $29,200,000. The preliminary TPC range for this project is $25,000,000 to $29,900,000.

[b] Other Project Costs (OPC) are funded through laboratory overhead.

6. Details of Project Cost Estimate

(Dollars in Thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design (PED)[a]			
Design	800	N/A	N/A
Contingency	100	N/A	N/A
Total, PED	900	N/A	N/A
Construction			
Other Construction	22,640	N/A	N/A
Contingency	5,660	N/A	N/A
Total Construction	28,300[b]	N/A	N/A
Total, TEC	29,200[b]	N/A	N/A
Contingency, TEC	5,760	N/A	N/A
Other Project Cost (OPC)[c]			
OPC except D&D			
Conceptual Planning	700	N/A	N/A
Startup	0	N/A	N/A
Total, OPC	700	N/A	N/A
Total, TPC[b]	29,900[b]	N/A	N/A
Total, Contingency	5,760	N/A	N/A

[a] All design will be complete in less than 18 months

[b] This project has not yet received CD-2 approval; funding estimates are consistent with the high end of the preliminary cost ranges. The preliminary TEC range for this project is $24,300,000 to $29,200,000. The preliminary TPC range for this project is $25,000,000 to $29,900,000.

[c] Other Project Costs are funded through laboratory overhead.

7. Funding Profile History

Request Year		(Dollars in Thousands) FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	Total
FY 2013	TEC	0	0	0	2,500	26,700	0	0	29,200[a]
	OPC[b]	400	300	0	0	0	0	0	700
	TPC	400	300	0	2,500	26,700[a]	0[a]	0[a]	29,900[a]

8. Related Operations and Maintenance Funding Requirements

Not Applicable.

9. Required D&D Information

Not Applicable.

10. Acquisition Approach

Not Applicable.

[a] This project has not yet received CD-2 approval; funding estimates are consistent with the high end of the preliminary cost ranges. The preliminary TEC range for this project is $24,300,000 to $29,200,000. The preliminary TPC range for this project is $25,000,000 to $29,900,000.

[b] Other Project Costs are funded through laboratory overhead.

12-SC-70, Science and User Support Building
SLAC National Accelerator Laboratory (SLAC), Menlo Park, California
Project Data Sheet is for Design and Construction

1. Significant Changes

The most recent DOE O 413.3B approved Critical Decision (CD) is CD-0, Approve Mission Need, which was approved August 26, 2010. The estimated preliminary Total Estimated Cost (TEC) range for this project is $59,000,000 to $64,000,000. The estimated preliminary Total Project Cost (TPC) range for this project is $60,000,000 to $65,000,000.

A Federal Project Director at the appropriate certification level will be assigned to this project prior to CD-1.

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

This PDS is an update of the FY 2012 PDS.

2. Design, Construction, and D&D Schedule

(Fiscal Quarter To Date)

	CD-0	CD-1	PED Complete	CD-2/3	CD-4	D&D Start	D&D Complete
FY 2012	8/26/2010	2Q FY 2012	4Q FY 2013	TBD	TBD	TBD	TBD
FY 2013	8/26/2010	3Q FY 2012	2Q FY 2013	2Q FY 2013[a]	4Q FY 2016[a]	3Q FY 2012[a]	4Q FY 2016[a]

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

3. Baseline and Validation Status

(Dollars in Thousands)

	TEC, PED	TEC Construction	TEC, Total	OPC[b] Except D&D	OPC, D&D	OPC, Total	TPC
FY 2012	5,000	59,000[c]	64,000[c]	1,000	TBD	1,000	65,000[c]
FY 2013	5,000	59,000[c]	64,000[c]	1,000	0	1,000	65,000[c]

[a] This project is pre-CD-2 and the estimated schedule is preliminary. Construction funds will not be executed without appropriate CD approvals.
[b] Other Project Costs are funded through laboratory overhead.
[c] This project has not yet received CD-2 approval; funding estimates are consistent with the high end of the preliminary cost ranges. The preliminary TEC range for this project is $59,000,000 to $64,000,000. The preliminary TPC range for this project is $60,000,000 to $65,000,000.

4. Project Description, Justification, and Scope

Mission Need

SLAC is an Office of Science laboratory that supports a large national and international community of scientific users performing cutting edge research in support of the Department of Energy mission. SLAC is home to research activities in materials and chemical sciences that build on ultrafast and advanced synchrotron techniques. SLAC also operates beamlines for structural biology and supports efforts in particle physics and particle astrophysics. SLAC operates and is strongly positioned by the Linac Coherent Light Source (LCLS) and the Stanford Synchrotron Radiation Light Source (SSRL).

The demand to use SLAC's unique research facilities is rapidly increasing. This has resulted in a critical gap in SLAC's mission capability due to inadequate centralized support for its user community and lack of modern, collaborative infrastructure to support a world-class research program.

The SLAC Science and User Support building (SUSB) will close the mission capability gap and ensure that the world-class research conducted by SLAC scientific staff and users is supported by modern, mission-ready facilities. Located at the entrance to the Laboratory, this building will be the first stop for all users and visitors to SLAC, and will bring together many of the Laboratory's user, visitor, and administrative services. This will enhance scientific productivity and collaboration that better supports the laboratory's cutting-edge discoveries and exceptional user research program.

Scope and Justification (12-SC-70, Science and User Support Building at SLAC)

A range of alternatives will be considered; however, the current proposed approach is to construct a building with an estimated area of 58,000 gsf to 72,000 gsf that will house a centrally located user support hub; the visitor's center; a new cafeteria; office space needed to centralize SLAC communications, security, and laboratory administration; and a state-of-the-art auditorium and conference space. The Science and User Support Building will replace the aging structure that currently holds Panofsky Auditorium and the cafeteria built in 1962, the same year SLAC was founded. In order to meet the congressional mandates for replacement, the project plans to demolish the Panofsky Auditorium building (approximately 19,000 gsf) and use banked excess for the balance. Note that the project does not yet have CD-2 approval, so some assumptions may change.

This project has not yet received CD-1 approval; therefore key performance parameters are to be determined.

FY 2013 construction funding will support construction activities on this project, such as site preparation, including project management and all associated support functions.

The project will be conducted in accordance with the project management requirements in DOE Order 413.3B, Program and Project Management for the Acquisition of Capital Assets, 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	5,000	5,000	4,500
FY 2013	0	0	500
Total, PED	5,000	5,000	5,000

(Dollars in Thousands)

	Appropriations	Obligations	Costs
Construction			
FY 2012	7,086	7,086	4,000
FY 2013	21,629	21,629	15,000
FY 2014	30,285	30,285	35,000
FY 2015	0	0	5,000
Total, Construction	59,000[a]	59,000[a]	59,000[a]
TEC			
FY 2012	12,086	12,086	8,500
FY 2013	21,629	21,629	15,500
FY 2014	30,285	30,285	35,000
FY 2015	0	0	5,000
Total, TEC	64,000[a]	64,000[a]	64,000[a]
Other Project Cost (OPC)[b]			
OPC except D&D			
FY 2011	500	500	500
FY 2012	0	0	0
FY 2013	0	0	0
FY 2014	300	300	300
FY 2015	200	200	200
Total, OPC except D&D	1,000	1,000	1,000

[a] This project has not yet received CD-2 approval; funding estimates are consistent with the high end of the preliminary cost ranges. The preliminary TEC range for this project is $59,000,000 to $64,000,000. The preliminary TPC range for this project is $60,000,000 to $65,000,000.
[b] Other Project Costs are funded through laboratory overhead.

(Dollars in Thousands)

	Appropriations	Obligations	Costs
Total Project Cost (TPC)			
FY 2011	500	500	500
FY 2012	12,086	12,086	8,500
FY 2013	21,629	21,629	15,500
FY 2014	30,585	30,585	35,300
FY 2015	200	200	5,200
Total, TPC[a]	65,000[a]	65,000[a]	65,000[a]

6. Details of Project Cost Estimate

(Dollars in Thousands)

	Current Total Estimate	Previous Total Estimate[a]	Original Validated Baseline
Total Estimated Cost (TEC)			
Design (PED)			
Design	4,150	4,150	N/A
Contingency	850	850	N/A
Total, PED	5,000	5,000	N/A
Construction			
Construction	47,200	5,669	N/A
Contingency	11,800	1,417	N/A
Total, Construction	59,000[b]	7,086	N/A
Total, TEC	64,000[b]	TBD	N/A
Contingency, TEC	12,650	2,267	N/A

[a] The funding amounts shown in table 6 in the FY 2012 Request to Congress only reflected funding through FY 2012.

[b] This project has not yet received CD-2 approval; funding estimates are consistent with the high end of the preliminary cost ranges. The preliminary TEC range for this project is $59,000,000 to $64,000,000. The preliminary Total Project Cost (TPC) range for this project is $60,000,000 to $65,000,000.

(Dollars in Thousands)

	Current Total Estimate	Previous Total Estimate[a]	Original Validated Baseline
OPC[b]			
Other OPC	500	500	N/A
Start-Up	300	300	N/A
Contingency	200	200	N/A
Total, OPC	1,000	1,000	N/A
Total, TPC	65,000[c]	10,619	N/A
Total, Contingency	12,850	2,467	N/A

7. Funding Profile History

(Dollars in Thousands)

Request Year		FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	Total
FY 2012	TEC	0	12,086	TBD	TBD	TBD	TBD
	OPC[b]	500	300	200	0	0	1,000
	TPC	500	12,386	TBD	TBD	TBD	TBD
FY 2013	TEC	0	12,086	21,629	30,285	0	64,000
	OPC[b]	500	0	0	300	200	1,000
	TPC	500	12,086	21,629	30,585[c]	200[c]	65,000[c]

8. Related Operations and Maintenance Funding Requirements

Not Applicable.

9. Required D&D Information

The Science and User Support Building will replace the aging structure that currently holds Panofsky Auditorium and the cafeteria, built in 1962, the same year SLAC was founded. In order to meet the congressional mandates for replacement, the project plans to demolish the Panofsky Auditorium building and use banked excess for the balance. Note that the project does not yet have CD-2 approval, so some assumptions may change.

[a] The funding amounts shown in table 6 in the FY 2012 Request to Congress only reflected funding through FY 2012.

[b] Other Project Costs are funded through laboratory overhead.

[c] This project has not yet received CD-2 approval; funding estimates are consistent with the high end of the preliminary cost ranges. The preliminary TEC range for this project is $59,000,000 to $64,000,000. The preliminary Total Project Cost (TPC) range for this project is $60,000,000 to $65,000,000.

10. Acquisition Approach

SLAC as the M&O contractor will have the primary responsibility for oversight of design and construction subcontracts, LEED, commissioning, and estimating services necessary to execute this project scope. Design will be performed by an architect-engineer (A-E) with the subcontract managed by the SLAC operating contractor. Note that the project does not yet have CD-2 approval, so some assumptions may change.

10-SC-70, Research Support Building and Infrastructure Modernization,
SLAC National Accelerator Laboratory (SLAC), Menlo Park, California
Project Data Sheet is for Design and Construction

1. Significant Changes

The most recent DOE O 413.3B Critical Decision (CD) is CD-2/3A, *Approve Performance Baseline and Start of Construction*, which was approved on December 20, 2010. The Total Estimated Cost (TEC) of this project is $96,000,000. The Total Project Cost (TPC) of this project is $97,400,000.

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

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

This PDS is an update of the FY 2012 PDS. Since that submittal, the estimate for project engineering and design (PED) activities has been revised downward from $6,900,000 to $6,429,000. The construction estimate has been revised upward by an equal amount such that there is no net increase in TEC.

2. Design, Construction, and D&D Schedule

(Fiscal Quarter or Date)

	CD-0	CD-1	PED Complete	CD-2/3A	CD-3B	CD-4	D&D Start	D&D Complete
FY 2010	10/10/2008	1Q FY 2010	2Q FY 2011	TBD	TBD	TBD	TBD	TBD
FY 2011	10/10/2008	11/3/2009	4Q FY 2011	4Q FY 2010	4Q FY 2012	1Q FY 2015	4Q FY 2011	2Q FY 2015
FY 2012	10/10/2008	11/3/2009	4Q FY 2011	12/20/2010	2Q FY 2013	3Q FY 2015	2Q FY 2011	4Q FY 2014
FY 2013	10/10/2008	11/3/2009	7/31/2011	12/20/2010	2Q FY 2013	3Q FY 2015	2Q FY 2011	4Q FY 2014

CD-0 – Approve Mission Need
CD-1 – Approve Alternative Selection and Cost Range
CD-2/3A – Approve Performance Baseline; Approve Start of Construction; RSB Building 52 and Building 28
CD-3B – Approve Start of Construction; Building 41
CD-4 – Approve Start of Operations or Project Closeout
D&D Start – Start of Demolition & Decontamination (D&D) work
D&D Complete – Completion of D&D work

3. Baseline and Validation Status

(Dollars in Thousands)

	TEC,PED	TEC Construction	TEC, Total	OPC[a] Except D&D	OPC, D&D	OPC, Total	TPC
FY 2010	8,900	TBD	TBD	1,400	TBD	TBD	TBD
FY 2011	8,900	87,100	96,000	1,400	N/A	1,400	97,400
FY 2012	6,900	89,100	96,000	1,400	N/A	1,400	97,400
FY 2013	6,429	89,571	96,000	1,400	N/A	1,400	97,400

4. Project Description, Justification, and Scope

Mission Need

SLAC National Accelerator Laboratory is an Office of Science laboratory that supports a large national and international community of scientific users performing cutting edge research in support of the Department of Energy mission. SLAC was originally founded to perform accelerator-based particle physics research. The laboratory mission has since broadened its focus to include photon science and non-accelerator based particle physics. Successfully carrying out this broadened mission is currently at risk given substandard buildings that do not provide the appropriate environment to conduct world class science or mission support functions.

SLAC's transition to a multi-program laboratory, combined with the condition and age of SLAC facilities drives the need to better align core research functions and modernize key support buildings. The most pressing infrastructure gaps are the lack of appropriate space to house and co-locate accelerator scientists and key mission support staff who are currently spread across the laboratory in outdated and inefficient facilities.

Scope and Justification (10-SC-70, Research Support Building and Infrastructure Modernization at SLAC)

The Research Support Building and Infrastructure Modernization project will correct these deficiencies by replacing numerous 40-year-old trailers that currently house the laboratory's accelerator scientists. This will improve accelerator research capabilities and efficiency by collocating Particle Physics, SSRL, and LCLS functions and enabling integration across programmatic boundaries, allowing these scientists to better support the science missions at the laboratory. In addition, renovation of existing buildings is proposed. These buildings house key mission support functions and were part of the original construction of the laboratory in the mid-1960s. Although the basic core and shell construction are sound, their interior and exterior spaces and utility systems are obsolete. Overall, the proposed project will upgrade working conditions for over 20% of the laboratory staff in a way that supports the laboratory vision of a unified culture with a strong sense of community between all scientific and support functions across the laboratory.

New construction is anticipated to be in the range of 53,000 to 95,000 square feet which may include more than one building; a minimum of 53,000 square feet of existing space will undergo renovation, and demolition of approximately 20,000 square feet will be completed to provide the site for the new construction. The remaining balance of gross square feet to be demolished to meet the one-for-one replacement will be from banked excess.

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[a] Other Project Costs are funded through laboratory overhead.

Key Performance Parameters

Description	Threshold Value (Minimum)	Objective Value (Maximum)
New Facilities (Building 52)	53,000 gsf	95,000 gsf
Renovated Facilities (Building 28 and Building 41)	53,000 gsf	70,000 gsf

FY 2013 funding will support the continuation of construction activities, including project management and all associated support functions. FY 2013 is the final year of funding for this project.

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 2010	6,429	6,429	3,039[a]
FY 2011	0	0	3,390
Total, PED	6,429	6,429	6,429
Construction			
FY 2010	471	471	0
FY 2011	40,694	40,694	13,900
FY 2012	12,024	12,024	38,000
FY 2013	36,382	36,382	29,000
FY 2014	0	0	7,800
FY 2015	0	0	871
Total, Construction	89,571	89,571	89,571

[a] FY 2012 PED has been updated to reflet actual final costs.

(Dollars in Thousands)

	Appropriations	Obligations	Costs
TEC			
FY 2010	6,900	6,900	3,039
FY 2011	40,694	40,694	17,290
FY 2012	12,024	12,024	38,000
FY 2013	36,382	36,382	29,000
FY 2014	0	0	7,800
FY 2015	0	0	871
Total, TEC	96,000	96,000	96,000
Other Project Cost (OPC)[a]			
OPC except D&D			
FY 2009	700	700	700
FY 2010	0	0	0
FY 2011	5	5	5
FY 2012	215	215	215
FY 2013	250	250	250
FY 2014	230	230	230
Total, OPC	1,400	1,400	1,400
Total Project Cost (TPC)			
FY 2009	700	700	700
FY 2010	6,900	6,900	3,039
FY 2011	40,699	40,699	17,295
FY 2012	12,239	12,239	38,215
FY 2013	36,632	36,632	29,250
FY 2014	230	230	8,030
FY 2015	0	0	871
Total, TPC	97,400	97,400	97,400

[a] Other Project Costs are funded through laboratory overhead.

6. Details of Project Cost Estimate

(Dollars in Thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design (PED)			
Design	6,429	6,306	6,306
Contingency	0	594	594
Total, PED	6,429	6,900	6,900
Construction			
Construction	67,447	72,494	72,494
Contingency	22,124	16,606	16,606
Total, Construction	89,571	89,100	89,100
Total, TEC	96,000	96,000	96,000
Contingency, TEC	22,124	17,200	17,200
OPC[a]			
Other OPC	700	700	700
Start-Up	481	514	514
Contingency	219	186	186
Total, OPC	1,400	1,400	1,400
Total, TPC	97,400	97,400	97,400
Total, Contingency	22,343	17,386	17,386

[a] Other Project Costs are funded through laboratory overhead.

7. Funding Profile History

(Dollars in Thousands)

Request Year		FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	Total
FY 2010	TEC	0	8,900	TBD	TBD	TBD	TBD	TBD
	OPC[a]	500	900	TBD	TBD	TBD	TBD	TBD
	TPC	500	9,800	TBD	TBD	TBD	TBD	TBD
FY 2011	TEC	0	6,900	33,100	19,700	36,300	0	96,000
	OPC[a]	700	100	100	150	300	50	1,400
	TPC	700	7,000	33,200	19,850	36,600	50	97,400
FY 2012	TEC	0	6,900	40,776	12,024	36,300	0	96,000
	OPC[a]	700	0	150	100	250	200	1,400
	TPC	700	6,900	40,926	12,124	36,550	200	97,400
FY 2013	TEC	0	6,900	40,694	12,024	36,382	0	96,000
	OPC[a]	700	0	5	215	250	230	1,400
	TPC	700	6,900	40,699	12,239	36,632	230	97,400

8. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy	FY 2014
Expected Useful Life	50 years
Expected Future Start of D&D of this capital asset	FY 2064

(Related Funding requirements)

(Dollars in Thousands)

	Annual Costs		Life Cycle Costs	
	Current Total Estimate	Previous Total Estimate	Current Total Estimate	Previous Total Estimate
Operations	146	399	7,300	10,266
Maintenance	633	1,722	31,650	44,481
Total, Operations & Maintenance	779	2,121	38,950	54,747

Portions of this project include renovation of existing space within existing buildings.

9. Required D&D Information

This project will include demolition of approximately 20,000 square feet to clear the proposed site for the new construction. The remaining balance of gross square feet to be demolished to meet the one-for-one replacement will be from banked excess.

10. Acquisition Approach

Design was performed by an architect-engineer (A-E) with the subcontract managed by the SLAC operating contractor. The A-E subcontractor was competitively selected based on demonstrated competence and qualifications to perform the required design services at a fair and reasonable price. A design-build approach will be used to procure construction of the new Research Support Building, and a traditional design-bid-build approach will be used for remaining portions of the construction. Competitive construction bids will be sought by the SLAC operating contractor.

10-SC-71, Energy Sciences Building, Argonne National Laboratory (ANL), Argonne, IL
Project Data Sheet is for Design and Construction

1. Significant Changes

The most recent DOE O 413.3B approved Critical Decision (CD) is CD-3, *Approve Start of Building Construction*, which was approved on June 15, 2011, with a Total Estimated Cost (TEC) $95,000,000. The Total Project Cost (TPC) of this project is $95,956,000.

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

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

This PDS is an update of the FY 2012 PDS. Since that submittal, the estimate for project engineering and design (PED) activities has been revised downward from $10,000,000 to $6,587,000. The construction estimate has been revised upward by an equal amount such that there is no net increase in TEC. Since the last submittal, Other Project Costs (OPC) has also been revised downward from $1,000,000 to $956,000 resulting in a net decrease in TPC. In addition, the Project upper bound Key Performance Parameter has been changed from 165,000 gsf to 190,000 gsf since the last submittal.

2. Design, Construction, and D&D Schedule

(Fiscal Quarter or Date)

	CD-0	CD-1	PED Complete	CD-2	CD-3A	CD-3	CD-4
FY 2010	10/10/2008	4Q FY 2009	2Q FY 2011	TBD	TBD	TBD	TBD
FY 2011	10/10/2008	09/02/2009	2Q FY 2011	2Q FY 2011	2Q FY 2011	2Q FY 2012	4Q FY 2014
FY 2012	10/10/2008	09/02/2009	2Q FY 2011	01/20/2011	N/A	3Q FY 2011	4Q FY 2014
FY 2013	10/10/2008	09/02/2009	3/25/2011	01/20/2011	N/A	6/15/2011	4Q FY 2014

CD-0 – Approve Mission Need
CD-1 – Approve Alternative Selection and Cost Ranges
CD-2 – Approve Performance Baseline
CD-3– Approve Start of Building Construction – Updated tailoring strategy has changed CD-3B to CD-3
CD-4 – Approve Start of Operations or Project Closeout

(Fiscal Quarter or Date)

	D&D Start	D&D Complete
FY 2010	TBD	TBD
FY 2011	N/A	N/A
FY 2012	N/A	N/A
FY 2013	N/A	N/A

D&D Start – Start of Demolition & Decontamination (D&D) work
D&D Complete –Completion of D&D work

3. Baseline and Validation Status

(Dollars in Thousands)

	TEC, PED	TEC, Construction	TEC, Total	OPC[a] Except D&D	OPC, D&D	OPC, Total	TPC
FY 2010	10,000	TBD	TBD	1,000	TBD	TBD	TBD
FY 2011	10,000	85,000	95,000	1,000	N/A	1,000	96,000
FY 2012	10,000	85,000	95,000	1,000	N/A	1,000	96,000
FY 2013	6,857	88,143	95,000	956	N/A	956	95,956

4. Project Description, Justification, and Scope

Mission Need

Research capabilities at ANL are currently hampered by antiquated, scientifically inadequate, and inefficient research space. The original site plan was designed when science research was done as a set of separate disciplines. Integrating different areas of science will enable multi-functionality and enhance capabilities of research funded by the Office of Science.

ANL research buildings dedicated to the SC energy research missions at ANL are all more than 40 years old. They require constant repair and frequently compromise or halt scientific research making them unable to meet modern standards for high resolution apparatus requiring vibration, electromagnetic, and thermal stability. Electrical power in these facilities is unstable and insufficient for modern synthesis and measurement instruments to operate at rated performance levels. Temperature and humidity controls were designed for human comfort only and not for state-of-the-art experimental performance, resulting in erratic temperature and humidity fluctuations over a few hours requiring frequent recalibration of apparatus to achieve sufficient measuring accuracy. Several key laboratories can operate only at night because of excessive vibration, temperature, and power fluctuations in the daytime, significantly impeding productivity. In addition to the functional inadequacies described above, safety and building code non-compliances further compromise ANL's ability to support SC and the Department's long-term energy goals. Antiquated and outdated electrical, fire protection, and ventilation systems have resulted in numerous National Electric and National Fire Protection Association code deficiencies. The age of these facilities and systems as well as the inability to obtain replacement parts has limited ANL's ability to correct these deficiencies via replacement or capital improvements.

Scope and Justification (10-SC-71, Energy Sciences Building at ANL)

The Energy Sciences Building (ESB) project will replace some of the oldest and least effective research space with between 125,000 and 190,000 gross square feet of new, environmentally stable and specialized multi-disciplinary laboratory space for core energy research at ANL. This new center will provide modern, 21st century, high-accuracy laboratory and office space for energy-related research and development (R&D) and associated space for support functions. The design utilizes efficient laboratory planning benchmarks as the basis for determining the size and configuration of space types. The design of the space also emphasizes more open, collaborative environments and flexibility to respond to future mission changes. In addition to the research laboratories, the building will include office space for researchers, small group conference rooms, equipment areas, restrooms, circulation space, and supporting infrastructure.

The objective of the ESB project is to provide the agile, flexible, and sustainable high-accuracy laboratory and office space to support scientific theory/simulation, materials discovery, characterization, and application of new energy-related materials and processes. Efficient, high-accuracy heating, ventilation, and air conditioning systems will be installed to support cutting edge research and the operation of sensitive instrumentation. Comparable space is not available at ANL. The scope of the

[a] Other Project Costs are funded through laboratory overhead.

project includes design, construction, and necessary furniture and equipment for the new facility as well as extension of existing site utilities to the new building. Risks were analyzed in accordance with DOE O 413,3B procedures and were found to be acceptable for the issuance of CD-3.

This project has secured “banked space” from prior Nuclear Footprint Reduction efforts at Argonne as well as demolition projects at other Office of Science facilities to meet the one for one requirement for offsetting space.

Key Performance Parameters

Description	Threshold Value (Minimum)	Objective Value (Maximum)
Facility Size	125,000 gsf	190,000 gsf

FY 2013 construction funding will support the completion of construction activities on this project, including project management and all associated support functions. FY 2013 is the final year of funding for this project and includes $14.62M for contingency.

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 2010	6,857	6,857	3,667
FY 2011	0	0	3,190
Total, PED	6,857	6,857	6,857
Construction			
FY 2010	1,143	1,143	0
FY 2011	14,970	14,970	6,800
FY 2012	40,000	40,000	48,000
FY 2013	32,030	32,030	29,200
FY 2014	0	0	4,143
Total, Construction	88,143	88,143	88,143

(Dollars in Thousands)

	Appropriations	Obligations	Costs
TEC			
FY 2010	8,000	8,000	3,667
FY 2011	14,970	14,970	9,990
FY 2012	40,000	40,000	48,000
FY 2013	32,030	32,030	29,200
FY 2014	0	0	4,143
Total, TEC	95,000	95,000	95,000
Other Project Cost (OPC)[a]			
OPC except D&D			
FY 2009	956	956	956
Total, OPC	956	956	956
Total Project Cost (TPC)			
FY 2009	956	956	956
FY 2010	8,000	8,000	3,667
FY 2011	14,970	14,970	9,990
FY 2012	40,000	40,000	48,000
FY 2013	32,030	32,030	29,200
FY 2014	0	0	4,143
Total, TPC	95,956	95,956	95,956

[a] Other Project Costs are funded through laboratory overhead.

6. Details of Project Cost Estimate

(Dollars in Thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design (PED)			
Design	6,857	8,334	6,857
Contingency	0	1,666	0
Total, PED	6,857	10,000	6,857
Construction			
Other Construction	73,491	70,707	73,491
Contingency	14,652	14,293	14,652
Total, Construction	88,143	85,000	88,143
Total, TEC	95,000	95,000	95,000
Contingency, TEC	14,652	15,959	14,652
Other Project Cost (OPC)[a]			
OPC except D&D			
Conceptual Planning	263	263	263
Conceptual Design	693	737	693
Contingency	0	0	0
Total, OPC	956	1,000	956
Total, TPC	95,956	96,000	95,956
Total, Contingency	14,652	15,959	14,652

[a] Other Project Costs are funded through laboratory overhead.

7. Funding Profile History

Request Year		FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	Total
		(Dollars in Thousands)					
FY 2010	TEC	0	10,000	TBD	TBD	TBD	TBD
	OPC[a]	1,000	0	0	0	0	TBD
	TPC	1,000	10,000	TBD	TBD	TBD	TBD
FY 2011	TEC	0	8,000	15,000	45,000	27,000	95,000
	OPC[a]	956	44	0	0	0	1,000
	TPC	956	8,044	15,000	45,000	27,000	96,000
FY 2012	TEC	0	8,000	15,000	40,000	32,000	95,000
	OPC[a]	956	44	0	0	0	1,000
	TPC	956	8,044	15,000	40,000	32,000	96,000
FY 2013	TEC	0	8,000	14,970	40,000	32,030	95,000
	OPC[a]	956	0	0	0	0	956
	TPC	956	8,000	14,970	40,000	32,030	95,956

8. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy	FY 2014
Expected Useful Life	50 years
Expected Future Start of D&D of this capital asset	FY 2064

(Related Funding requirements)

(Dollars in Thousands)

	Annual Costs		Life Cycle Costs	
	Current Total Estimate	Previous Total Estimate	Current Total Estimate	Previous Total Estimate
Operations	733	733	96,182	96,182
Maintenance	1,153	1,153	37,363	37,363
Total, Operations & Maintenance	1,886	1,886	133,545	133,545

9. Required D&D Information

This project has secured "banked space" from prior Nuclear Footprint Reduction efforts at Argonne as well as demolition projects at other Office of Science facilities to meet the one for one requirement for offsetting space.

10. Acquisition Approach

The ESB project Acquisition Strategy was approved on January 7, 2009.

The M&O contractor will have prime responsibility for oversight of both the design and construction subcontracts.

Various acquisition alternatives were considered for this project. After considering all alternatives in relation to the schedule, size, and risk, the use of a tailored design-bid-build approach with design by an architectural/engineering firm, construction management services through the industrial partnership, and construction by a general contractor, all led by the M&O contractor integrated project team, was deemed to provide the best construction delivery method and the lowest risk. In addition, the M&O contractor's standard procurement practice is to use firm fixed-priced contracts, and the M&O contractor has extensive experience in project management, construction management, and ES&H management systems in the acquisition of scientific facilities.

10-SC-72, Renovate Science Laboratories, Phase II, Brookhaven National Laboratory (BNL), Upton, New York
Project Data Sheet is for Design and Construction

1. Significant Changes

The most recent DOE O 413.3B approved Critical Decision (CD) is CD-3b, *Approve Start Construction*, which was approved on June 15, 2011. The Total Estimated Cost (TEC) of this project is $50,000,000. The Total Project Cost (TPC) of this project is $50,800,000.

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

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

This PDS is an update of the FY 2012 PDS. Since that submittal, the estimate for project engineering and design (PED) activities has been revised downward from $6,000,000 to $4,960,000. The construction estimate has been revised upward by an equal amount, and there is no net change to the TPC.

2. Design, Construction, and D&D Schedule

(Fiscal Quarter To Date)

	CD-0	CD-1 (Design Start)	PED Complete	CD-2/3a	CD-3b	CD-4
FY 2010	10/10/2008	4Q FY 2009	3Q FY 2011	TBD	TBD	TBD
FY 2011	10/10/2008	9/2/2009	2Q FY 2011	1Q FY 2011	4Q FY 2011	2Q FY 2014
FY 2012	10/10/2008	9/2/2009	2Q FY 2011	12/20/2010	4Q FY 2011	3Q FY 2014
FY 2013	10/10/2008	9/2/2009	2/28/2011	12/20/2010	6/15/2011	3Q FY 2014

CD-0 – Approve Mission Need
CD-1 – Approve Alternative Selection and Cost Range
CD-2/3a – Approve Performance Baseline and Start of Site Preparation
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[a]	OPC, D&D	OPC, Total	TPC
FY 2010	7,000	TBD	TBD	800	TBD	TBD	TBD
FY 2011	7,000	43,000	50,000	800	TBD	800	50,800
FY 2012	6,000	44,000	50,000	800	N/A	800	50,800
FY 2013	5,100	44,900	50,000	800	N/A	800	50,800

[a] Other Project Costs are funded through laboratory overhead.

4. Project Description, Justification, and Scope

Mission Need

BNL maintains primary focus in the physical energy, life sciences, environmental sciences, energy technology areas. Building 510 is a key facility for major activities in particle physics, experimental and theoretical nuclear physics, accelerator science, condensed matter physics, and materials science research. This building is home for scientists at the Relativistic Heavy Ion Collider and is the center for the U.S. group that works at the Large Hadron Collider (LHC) at CERN. Building 555 (the Chemistry Department) is essential to research supported by SC's Basic Energy Science (BES) program as it's the primary site for wet chemistry, and, in the future, will house other materials synthesis programs funded by BES. Building 555 is a key facility for research, theory, and computation in chemical and molecular sciences and for structural analysis of biological systems sciences. This building is strongly connected to BNL's CFN, NSLS, the New York Blue supercomputer, and the future NSLS-II.

The laboratories in Building 510 were constructed in 1962 and are desperately in need of renovation and modernization in order to keep pace with the highly complex and rapidly changing technologies required for work on advanced new detectors. This work involves sophisticated electronics, high precision mechanical assemblies, and extremely clean work areas for detectors such as silicon or gas filled devices. A task force conducted a condition assessment of the laboratories and developed a list of deficiencies that included damaged floors and ceilings, roof and ceiling leaks, old and unused plumbing, poor lighting levels, decrepit lab facilities, poor temperature control and ventilation, significant particulate discharge from heating, ventilation, and air conditioning systems, high electromagnetic interference noise on electrical power in certain laboratories, and lack of fire sprinkler protection.

Building 555 has a robust design for chemical sciences research but was constructed in 1966 and now has a number of substantial limitations for current research needs. While Building 555 has an effective design for wet chemistry, it needs to be renovated to address very serious infrastructure quality issues that have grown over the years. Its design can also accommodate the evolving need for laser and instrumentation space for many of the physical methods in use, but an upgrade of facilities for air, water, and electrical is critical, and selective lab reconfiguration is needed to best meet advanced instrumentation needs.

Scope and Justification (10-SC-72, Renovate Science Laboratories, Phase II, at BNL)

The Renovate Science Laboratories, Phase II project will upgrade and rehabilitate existing, obsolete, and unsuitable systems in Buildings 510 (Physics) and 555 (Chemistry) to provide safe, modern, efficient, and sustainable facilities for advanced detector research and chemistry research. For example, the renovation of the heating, ventilating and air conditioning system will eliminate the fine dust that accumulated due to corrosion which currently covers instruments and working surfaces. It will also provide stable temperatures necessary for high accuracy research. The fire suppression system will also be upgraded to comply with modern building codes. This project will improve the working environment of scientists associated with the NP, HEP, and BES programs and boost operational efficiency, save energy through occupation of more efficient buildings, and provide facilities the meet ES&H codes to improve safety.

Key Performance Parameters

Description	Threshold Value (Minimum)	Objective Value (Maximum)
Building 510	Revitalization and modernization of architectural, mechanical, electrical and fire protection systems located in the 3-story laboratory and office wing. Includes demolition as required and startup testing of building systems. Hazard Analysis Report (HAR) approved and Beneficial Occupancy Readiness Evaluation (BORE) conducted.	Renovation of B510 Seminar Wing.
Building 555	Revitalization and modernization of architectural, mechanical, electrical and fire protection systems located in the second and third floors of the west wing. Includes demolition as required and startup testing of building systems. HAR approved and BORE conducted.	Elevator upgrades and partition wall upgrades in chemistry labs.

FY 2013 construction funds will support the continuation of construction activities on this project, including project management and all associated support functions. FY 2013 is the final year of funding for this project.

The project is being conducted in accordance with the project management requirements in DOE O 413.3B and all appropriate project management requirements have been met.

5. Financial Schedule

(Dollars in Thousands)

	Appropriations	Obligations	Costs[a]
Total Estimated Cost (TEC)			
PED			
FY 2010	5,000	5,000	3,406
FY 2011	100	100	1,554
Total, PED	5,100	5,100	4,960[b]

[a] All costs through FY 2011 reflect actual expeditures.

[b] FY 2010 PED has been updated to reflect actual final costs.

(Dollars in Thousands)

	Appropriations	Obligations	Costs[a]
Construction			
FY 2011	14,870	14,870	1,119
FY 2012	15,500	15,500	18,712
FY 2013	14,530	14,530	23,993
FY 2014	0	0	1,216
Total, Construction	44,900	44,900	45,040
TEC			
FY 2010	5,000	5,000	3,406
FY 2011	14,970	14,970	2,673
FY 2012	15,500	15,500	18,712
FY 2013	14,530	14,530	23,993
FY 2014	0	0	1,216
Total, TEC	50,000	50,000	50,000
Other Project Cost (OPC)[a]			
OPC except D&D			
FY 2009	737	737	737
FY 2010	0	0	15
FY 2011	63	63	0
FY 2012	0	0	48
Total, OPC	800	800	800
Total Project Cost (TPC)			
FY 2009	737	737	737
FY 2010	5,000	5,000	3,421
FY 2011	15,033	15,033	2,673
FY 2012	15,500	15,500	18,760
FY 2013	14,530	14,530	23,993
FY 2014	0	0	1,216
Total, TPC	50,800	50,800	50,800

[a] Other Project Costs are funded through laboratory overhead

6. Details of Project Cost Estimate

(Dollars in Thousands)

	Current Total Estimate[a]	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design (PED)			
Design	4,960	5,007	5,007
Contingency	0	993	993
Total, PED	4,960	6,000	6,000
Construction			
Other Construction	36,490	36,363	36,363
Contingency	8,550	7,637	7,637
Total, Construction	45,040	44,000	44,000
Total, TEC	50,000	50,000	50,000
Contingency, TEC	8,550	8,630	8,630
Other Project Cost (OPC)[b]			
OPC except D&D			
Conceptual Planning	150	150	150
Conceptual Design	650	650	650
Contingency	0	0	0
Total, OPC	800	800	800
Total, TPC	50,800	50,800	50,800
Total, Contingency	8,550	8,630	8,630

[a] All costs through FY 2011 reflect actual expeditures.
[b] Other Project Costs are funded through laboratory overhead.

7. Funding Profile History

Request Year		(Dollars in Thousands) FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	Total
FY 2010	TEC	0	7,000	TBD	TBD	TBD	TBD
	OPC[a]	800	0	0	0	0	800
	TPC	800	7,000	TBD	TBD	TBD	TBD
FY 2011	TEC	0	5,000	15,000	22,000	8,000	50,000
	OPC[a]	737	63	0	0	0	800
	TPC	737	5,063	15,000	22,000	8,000	50,800
FY 2012	TEC	0	5,000	15,000	15,500	14,500	50,000
	OPC[a]	737	63	0	0	0	800
	TPC	737	5,063	15,000	15,500	14,500	50,800
FY 2013	TEC	0	5,000	14,970	15,500	14,530	50,000
	OPC[a]	737	0	63	0	0	800
	TPC	737	5,000	15,033	15,500	14,530	50,800

8. Related Operations and Maintenance Funding Requirements

Project is a renovation of existing space within existing buildings.

Start of Operation or Beneficial Occupancy (fiscal quarter or date)	3Q FY 2014
Expected Useful Life (number of years)	30
Expected Future Start of D&D of this capital asset (fiscal quarter)	N/A

9. Required D&D Information

The project is a renovation of existing space. No new space will be constructed.

10. Acquisition Approach

Design will be performed by an architect-engineer (A-E) with the subcontract managed by the BNL operating contractor. The A-E will be competitively selected based on qualifications. After completion of the design, the BNL operating contractor will solicit offers from prospective large and small business general construction firms, and award a firm fixed price construction subcontract. Evaluation of offers will include consideration of each offeror's relative experience, safety record, past performance in successfully completing similar construction projects, and cost. Award will then be made to one qualified responsible, responsive offeror.

[a] Other Project Costs are funded through laboratory overhead.

Safeguards and Security
Funding Profile by Subprogram and Activity

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Protective Forces	36,522	35,453	33,750
Security Systems	11,625	9,908	13,685
Information Security	4,775	4,753	4,344
Cyber Security	15,604	16,460	18,422
Personnel Security	5,489	5,059	5,000
Material Control and Accountability	2,327	2,189	2,173
Program Management	7,444	6,751	6,626
Total, Safeguards and Security	83,786	80,573[a]	84,000

[a] The FY 2012 appropriation is reduced by $1,427,000 for the Safeguards and Security share of the DOE-wide $73,300,000 rescission for contractor pay freeze savings. The FY 2013 budget request reflects the FY 2013 impact of the contractor pay freeze.

Public Law Authorizations

Public Law 95–91, "Department of Energy Organization Act", 1977
Public Law 109–58, "Energy Policy Act of 2005"
Public Law 110–69, "America COMPETES Act of 2007"
Public Law 111–358, "America COMPETES Act of 2010"

Overview and Benefits

The Safeguards and Security (S&S) program mission is to support Departmental research at SC laboratories by ensuring appropriate levels of protection against unauthorized access, theft or destruction of Department assets, and hostile acts that may cause adverse impacts on fundamental science, national security, or the health and safety of DOE and contractor employees, the public, and the environment.

Global information sharing and open scientific collaboration is required for SC to successfully produce scientific breakthroughs. As a result, campuses and networks have been established to allow the exchange and access of scientific information. These efforts present security challenges across the national laboratory system. The SC Safeguards and Security program is designed to ensure that appropriate measures are in place to address these challenges. Specifically, the program has established the following priorities: to protect special, source, and other nuclear materials, radioactive material, and classified and unclassified controlled information at SC laboratories; to provide physical controls to SC national laboratory facilities to mitigate other security risks, including risks to facilities and laboratory employees, to an acceptable level; to provide cyber security controls for SC national laboratory information systems to protect data while enabling the mission; and to assure site security programs result in the secure workplace required to facilitate scientific advances.

The S&S program provides the support necessary to ensure the SC mission can be conducted in an open and collaborative environment that is secure from acts which may cause adverse impacts on the continuity of the program. Because SC laboratories collaborate with universities and research facilities in every corner of the globe, the physical and virtual security posture at SC laboratories must be flexible and supportive of these information exchanges and collaborative efforts. As a result, the S&S program is built on a foundation that enables the program to adjust protection levels at each facility in response to changes in risks and consequences for that facility.

To accomplish its mission, the S&S program is organized into seven functional areas: Protective Forces, Security Systems, Information Security, Cyber Security, Personnel Security, Material Control and Accountability, and Program Management.

Program Planning and Management

The program is managed using the proven program management principles and approaches applied to other SC programs. To ensure close integration with laboratory operations, S&S employs a fully collaborative and transparent partnership with site offices and laboratory managers.

SC uses a standardized risk-based approach for protection program planning that provides an information baseline for use in integrating S&S considerations, facilitates management evaluation of program elements, determines appropriate resources, and establishes a cost-benefit basis for analyses and comparison. SC sites assess the threat to mission specific assets and processes and implement baseline security elements to mitigate the resulting risk. The result of these efforts is a resource proposal and a site specific S&S Baseline Level of Protection. This baseline level of protection enables the SC research mission at the laboratories in several ways:

- It relies on national standards and rigorous peer reviews where possible, appropriately aligns risk tolerance and acceptance, and recognizes the diversity in the SC sites.
- It provides for the scalability of requirements, defines clear roles and responsibilities, and aligns accountability for performance with the appropriate Federal and contractor management.
- It encourages the use of technology where appropriate and incorporates the use of risk assessments to drive decisions on protection elements that may exceed or be below the baseline.

SC began implementation of a Security Baseline Level of Protection in FY 2011, but full implementation will take several years. Execution of FY 2011 and FY 2012 funding is based on the outcome of the risk assessments used as the basis for each site's level of protection. The outcome of those evaluations is the basis for funding requested in FY 2013 and will be the basis for future budget requests.

Explanation of Funding Changes

Consistent with priorities and assumptions, the increased FY 2013 request supports continued implementation of the Security Baseline Level of Protection while also maintaining support for current activities to ensure security is maintained during transition. The funds also support infrastructure investments in site access control systems and upgrades necessary to address Homeland Security Presidential Directive-12 (HSPD-12) requirements, address near-term cyber security threats, and support program enhancements to diminish the likelihood of successful cyber attacks in the future.

(Dollars in Thousands)

	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Protective Forces	35,453	33,750	-1,703

The request is decreased to accommodate funding allocations in Cyber Security and provide the needed enhancements to support a flexible cyber security program capable of responding to emerging threats at SC Laboratories. Implementation of the SC Security Baseline Level of Protection has permitted site-specific incremental reductions in Protective Forces without increasing risk. Funding at this level maintains security posture at a level that is consistent with laboratory needs and supports the equipment, facilities, and training necessary to ensure effective performance.

	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Security Systems	9,908	13,685	+3,777

The increased request is for the required infrastructure investments in federal access control systems and upgrades necessary to address the Homeland Security Presidential Directive-12 (HSPD-12).

	(Dollars in Thousands)		
	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Information Security	4,753	4,344	-409
The request is decreased to accommodate funding allocations in Cyber Security. Funding at this level will ensure proper document marking, storage, and protection of information.			
Cyber Security	16,460	18,422	+1,962
The increased request provides funding to address cyber security needs made apparent by recent attacks and program enhancements needed to ensure that laboratories are properly protected based on individual threat levels. Funding will be used to support threat assessments, risk management, configuration management, and network management.			
Personnel Security	5,059	5,000	-59
The request is decreased to accommodate funding allocations in Cyber Security. Funding at this level maintains support for Personnel Security at all SC laboratories.			
Material Control and Accountability	2,189	2,173	-16
The request is decreased to accommodate funding allocations in Cyber Security. Funding at this level provides resources to maintain essential security activities.			
Program Management	6,751	6,626	-125
The request is decreased to accommodate funding allocations in Cyber Security. Funding at this level maintains direction, oversight and administration, and security program planning.			
Total, Safeguards and Security	80,573	84,000	+3,427

Protective Forces

Overview

The Protective Forces element supports security officers, access control officers, and security policy officers assigned to protect S&S interests. Activities within this element include access control and security response operations as well as physical protection of the Department's critical assets and SC facilities. In addition, activities to maintain operations are aimed at providing effective response to emergency situations, random prohibited article inspections, security alarm monitoring, and performance testing of the protective force response to various event scenarios.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	Funding for Protective Forces ensured that security personnel were in place at SC laboratories where they are needed. Services provided by these forces included screening people and materials for site/facility entry; patrolling the laboratory in search of unauthorized persons and evidence of crime; and monitoring, assessing, and dispatching a response to investigate alarms and reported events. Protective forces also provided emergency management support for natural disasters, and traffic and crowd control for events.	36,522
2012 Enacted	Funding in FY 2012 maintains the necessary protective forces and the equipment, facilities, and training needed to ensure effective performance.	35,453
2013 Request	Funding requested in FY 2013 decreases to accommodate funding allocations in Cyber Security and provide the needed enhancements to support a flexible cyber security program capable of responding to emerging threats at SC Laboratories. SC Security Baseline Level of Protection implementation has permitted site-specific incremental reductions in Protective Forces without increasing risk. Funding maintains the current security posture at a level that is consistent with SC laboratory needs.	33,750

Security Systems

Overview

The Security Systems element provides physical protection of Departmental material, equipment, property, and facilities, including buildings, fences, barriers, lighting, sensors, surveillance devices, entry control devices, access control systems, and power systems operated and used to support the protection of DOE property and other interests of national security. This element is responsible for entry and access control to ensure individuals entering and leaving facilities are authorized and do not introduce prohibited articles into or remove DOE property. This includes managing barriers, security storage, and lock programs to restrict, limit, delay, or deny entry.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	Funding for Security Systems provided for the installation, operation, and maintenance and repair of security systems (e.g., automated access controls, communications equipment, and explosives detection equipment) at SC laboratories. Funding also provided services to ensure the effectiveness of these systems, including performance testing, intrusion detection and assessment, and access enrollment.	11,625
2012 Enacted	Funding in FY 2012 maintains the systems currently in place, including S&S personnel required to operate and service them.	9,908
2013 Request	Funding requested In FY 2013 supports the required investments in federal access control systems and upgrades (e.g., badge card readers and access system software and hardware) necessary to meet HSPD-12 requirements.	13,685

Information Security

Overview

The Information Security element provides support for execution of the administrative policies and procedures to ensure that sensitive and classified information is accurately and consistently indentified, reviewed, marked, and appropriately protected and, ultimately destroyed. Specific activities within this element include management, planning, training, and oversight for maintaining security containers and combinations, marking documents, and administration of control systems, operations security, special access programs, technical surveillance countermeasures, and classification and declassification determinations.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	Funding for Information Security provided for personnel, equipment, and systems necessary to ensure sensitive and classified information (e.g., classified documents, unclassified controlled nuclear information, and personal identity information) is properly safeguarded at SC laboratories. Activities included document and material classification and declassification, document marking and storage, and assessing and reporting security infractions.	4,775
2012 Enacted	Funding in FY 2012 maintains the level of efforts necessary to provide for S&S personnel as well as equipment such as alarm systems and technical security countermeasures.	4,753
2013 Request	Funds requested in FY 2013 maintain Information Security efforts to ensure proper document marking, storage, and protection of information. The request is decreased to accommodate funding allocations to Cyber Security.	4,344

Cyber Security

Overview

The Cyber Security element provides appropriate security controls for electronically processed, transmitted, or stored sensitive and classified information. Security controls ensure that information systems, including the information contained within the systems, maintain confidentiality, integrity, and availability in a manner consistent with the SC Research mission and possible threats.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	Funding for Cyber Security provided for the necessary activities to protect SC laboratory computing resources and data against unauthorized access or modification of information, as well as ensuring data availability. These activities included threat assessments, risk management, configuration management, certification/accreditation, training, and network monitoring. These activities are implemented by an Information Systems Security Manager, a Certification Agent, and full time Information System Security Officers.	15,604
2012 Enacted	Funding in FY 2012 provides for activities to protect SC laboratory computer resources and data. Consistent with agency-wide guidance, the requested amount reflects the removal of some functions previously charged to Cyber Security that will instead be funded by SC laboratory overhead.	16,460
2013 Request	The increased funding request in FY 2013 addresses emerging cyber security threats and implements an improved cyber security program that ensures laboratories are providing appropriate levels of protections for site specific risk environments and threat levels. Funding will be used to support threat assessments, risk management, configuration management, and network management.	18,422

Personnel Security

Overview

The Personnel Security element encompasses the processes for security clearance determinations at each site to ensure that individuals are eligible for access to classified information or matter. This element also includes the management of clearance programs, adjudication, security education and awareness programs for Federal and contractor employees, and processing and hosting approved foreign visitors.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	Funding for Personnel Security provided the necessary laboratory S&S personnel to grant individuals access to classified matter and/or special nuclear material and to allow foreign nationals' access to SC facilities, consistent with agency procedures. This element also funded security investigations for federal field personnel and security awareness programs for employees.	5,489
2012 Enacted	Funding in FY 2012 maintains support for Personnel Security at all SC laboratories.	5,059
2013 Request	Funds requested in FY 2013 maintain support and Personnel Security efforts at all SC laboratories. The request is decreased to accommodate funding increases in Cyber Security.	5,000

Material Control and Accountability

Overview

The Material Control and Accountability (MC&A) element provides assurance that Departmental materials are properly controlled and accounted for at all times. This element supports administration, including performance testing and assessing the levels of protection, control, and accountability required for the types and quantities of materials at each facility; documenting facility plans for materials control and accountability; assigning authorities and responsibilities for MC&A functions; and establishing programs to detect and report occurrences such as material theft, the loss of control or inability to account for materials, or evidence of malevolent acts. MC&A programs are designed to deter theft and diversion of nuclear material by both outside and inside adversaries. The level of control and accountability is graded based on the consequences of their loss.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	Funding for Material Control and Accountability provides for establishing, controlling, and tracking inventories of special and other accountable nuclear material at SC laboratories. Activities supported by these funds include measurements, quality assurance, accounting, containment, surveillance, and physical inventory.	2,327
2012 Enacted	Funding in FY 2012 ensures that proper protection of material is sustained.	2,189
2013 Request	Funding requested in FY 2013 provides resources for essential requirements and does not include new or adjusted requirements. The request is decreased to accommodate funding allocations in Cyber Security.	2,173

Program Management

Overview

The Program Management element coordinates the management of Protective Forces, Security Systems, Information Security, Personnel Security, Cyber Security, and Material Control and Accountability to achieve and ensure appropriate levels of protections are in place. Program Management also puts mechanisms in place to communicate expectations and assess contractor performance and corrective actions to assure continuous improvement.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	Funding for Program Management provides for the oversight, administration, and planning for security programs at SC laboratories. Planning activities include developing annual operating plans and site S&S plans, conducting vulnerability analyses and performance testing, managing security incident reporting, and conducting surveys and self-assessments.	7,444
2012 Enacted	Funding in FY 2012 maintains direction, oversight, administration, and security program planning. The request decreases due to priority shifts in other critical security elements.	6,751
2013 Request	Funding requested in FY 2013 maintains efforts to ensure security procedures and policy support the SC research mission. The request is decreased to accommodate funding allocations in Cyber Security.	6,626

Supporting Information

Operating Expenses, Capital Equipment and Construction Summary

(Dollars in Thousands)

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Operating Expenses	82,526	80,573	84,000
Capital Equipment	220	0	0
General Plant Projects	1,040	0	0
Total, Safeguards and Security	83,786	80,573	84,000

Estimates of Security Cost Recovered by Science, Safeguards and Security

The FY 2013 budget request allows sites to maintain program elements at balanced levels and implement an appropriate security posture at each laboratory. In order to ensure S&S program funds are used to support the DOE mission, laboratories will recover costs for any unique security needs required to support Work for Others customers. Estimates of those costs are shown below.

(Dollars in Thousands)

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Ames National Laboratory	40	40	140
Argonne National Laboratory	1,044	1,440	1,050
Brookhaven National Laboratory	810	950	1,000
Lawrence Berkeley National Laboratory	870	1,547	670
Oak Ridge Institute for Science and Education	440	400	440
Oak Ridge National Laboratory	4,300	4,734	4,500
Pacific Northwest National Laboratory	2,400	3,249	3,881
Princeton Plasma Physics Laboratory	29	35	30
SLAC National Accelerator Laboratory	70	2,794	68
Total, Security Cost Recovered	10,003	15,189	11,779

Science Program Direction
Funding Profile by Category

	(Dollars in Thousands/Whole FTEs)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Headquarters			
Salaries and Benefits	54,744	51,887	55,507
Travel	2,121	2,190	2,190
Support Services	14,126	9,934	10,929
Other Related Expenses	13,697	13,617	17,065
Total, Headquarters	84,688	77,628	85,691
Full Time Equivalents	318	330	343
Office of Scientific and Technical Information			
Salaries and Benefits	6,970	5,904	6,176
Travel	86	62	62
Support Services	1,197	1,275	1,771
Other Related Expenses	1,179	959	891
Total, Office of Scientific and Technical Information	9,432	8,200	8,900
Full Time Equivalents	57	48	49
Field Offices			
Chicago Office			
Salaries and Benefits	24,555	21,938	25,096
Travel	234	276	276
Support Services	2,881	2,162	2,265
Other Related Expenses	4,291	3,820	3,999
Total, Chicago Office	31,961	28,196	31,636
Full Time Equivalents	185	177	190

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Oak Ridge Office			
Salaries and Benefits	28,682	25,244	26,894
Travel	322	252	252
Support Services	4,528	4,137	4,333
Other Related Expenses	4,946	4,410	4,592
Total, Oak Ridge Office	38,478	34,043	36,071
Full Time Equivalents	237	228	233
Ames Site Office			
Salaries and Benefits	529	533	549
Travel	17	12	12
Total, Ames Site Office	546	545	561
Full Time Equivalents	3	3	3
Argonne Site Office			
Salaries and Benefits	3,462	3,586	4,030
Travel	11	81	81
Support Services	77	274	287
Other Related Expenses	58	33	35
Total, Argonne Site Office	3,608	3,974	4,433
Full Time Equivalents	22	22	24
Berkeley Site Office			
Salaries and Benefits	3,664	3,848	3,963
Travel	96	50	50
Support Services	455	0	0
Other Related Expenses	130	56	59
Total, Berkeley Site Office	4,345	3,954	4,072
Full Time Equivalents	22	22	22

(Dollars in Thousands/Whole FTEs)

	(Dollars in Thousands/Whole FTEs)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Brookhaven Site Office			
Salaries and Benefits	4,090	4,010	4,130
Travel	90	74	74
Support Services	215	546	571
Other Related Expenses	481	240	252
Total, Brookhaven Site Office	4,876	4,870	5,027
Full Time Equivalents	26	26	26
Fermi Site Office			
Salaries and Benefits	2,064	2,155	2,220
Travel	48	46	46
Support Services	2	11	11
Other Related Expenses	34	31	33
Total, Fermi Site Office	2,148	2,243	2,310
Full Time Equivalents	15	15	15
New Brunswick Laboratory			
Salaries and Benefits	4,128	4,211	4,337
Travel	63	68	68
Support Services	847	1,523	1,596
Other Related Expenses	1,094	138	144
Total, New Brunswick Laboratory	6,132	5,940	6,145
Full Time Equivalents	29	29	29
Oak Ridge National Laboratory Site Office			
Salaries and Benefits	4,109	3,828	5,771
Travel	71	56	56
Support Services	175	73	76
Other Related Expenses	0	41	46
Total, Oak Ridge National Laboratory Site Office	4,355	3,998	5,949
Full Time Equivalents	29	29	43

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
	(Dollars in Thousands/Whole FTEs)		
Pacific Northwest Site Office			
Salaries and Benefits	4,787	4,740	4,882
Travel	132	105	105
Support Services	172	174	182
Other Related Expenses	197	151	161
Total, Pacific Northwest Site Office	5,288	5,170	5,330
Full Time Equivalents	33	33	33
Princeton Site Office			
Salaries and Benefits	1,519	1,676	1,726
Travel	36	28	28
Support Services	9	4	5
Other Related Expenses	97	55	57
Total, Princeton Site Office	1,661	1,763	1,816
Full Time Equivalents	10	10	10
SLAC Site Office			
Salaries and Benefits	2,616	2,506	2,581
Travel	66	30	30
Support Services	121	11	11
Other Related Expenses	52	18	19
Total, SLAC Site Office	2,855	2,565	2,641
Full Time Equivalents	15	15	15
Thomas Jefferson Site Office			
Salaries and Benefits	2,098	1,840	1,895
Travel	25	31	31
Support Services	21	3	4
Other Related Expenses	3	37	39
Total, Thomas Jefferson Site Office	2,147	1,911	1,969
Full Time Equivalents	13	13	13

	(Dollars in Thousands/Whole FTEs)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Total Field Offices			
Salaries and Benefits	86,303	80,115	88,074
Travel	1,211	1,109	1,109
Support Services	9,503	8,918	9,341
Other Related Expenses	11,383	9,030	9,436
Total, Field Offices	108,400	99,172	107,960
Full Time Equivalents	639	622	656
Total PD			
Salaries and Benefits	148,017	137,906	149,757
Travel	3,418	3,361	3,361
Support Services	24,826	20,127	22,041
Other Related Expenses	26,259	23,606	27,392
Total, PD	202,520	185,000	202,551
Full Time Equivalents[a]	1,014	1,000	1,048

[a] FY 2011 reflects actual FTE usage, whereas FY 2012 and FY 2013 reflect the FTE ceiling. The FY 2011 FTE ceiling was 1,072.

Public Law Authorizations

Public Law 95-91, "Department of Energy Organization Act", 1977
Public Law 109-58, "Energy Policy Act of 2005"
Public Law 110-69, "America COMPETES Act of 2007"

Overview

The Office of Science's Program Direction (PD) mission is to sustain and support a skilled and motivated Federal workforce to develop and oversee SC investments in world-leading scientific research that delivers discoveries and technological innovations needed to solve our Nation's energy and environmental challenges, and enables the United States to maintain its global competitiveness. Providing easy public access to DOE's scientific findings further leverages the Federal science investment and advances the scientific enterprise.

Utilizing 4.0% of the total FY 2013 SC budget, Program Direction strives to provide an efficient and cost-effective corporate infrastructure for business management and stewardship of the resources necessary for SC to execute its mission. Carrying out SC's mission requires not only highly skilled scientific and technical program and project managers, but experts in areas such as acquisition; finance; legal; construction and infrastructure management; and environmental, safety, and health oversight. National challenges in energy, environmental stewardship, and nuclear security and continued U.S. innovation and scientific competitiveness, all rely upon transformational basic research. Oversight of DOE's basic research portfolio, which includes grants and contracts supporting approximately 25,000 researchers located at about 300 universities and 17 national laboratories, as well as supervision of major construction projects, is a Federal responsibility. SC also supports research by providing and maintaining state-of-the-art user facilities—the large machines of modern science. These facilities offer capabilities that are unmatched and enable U.S. researchers and industries to remain at the forefront of science, technology, and innovation. With adequate staffing levels and a workforce balanced with appropriate skills, education, and experience, SC is an effective and efficient steward that utilizes taxpayer dollars for maximum national benefit.

SC's Federal workforce plans, executes, and manages science programs that meet critical national needs.

Headquarters (HQ) Federal Workforce Duties:

- Strategically maintain a balanced research portfolio that includes high-risk, high-reward research to maximize the program's potential to achieve mission goals and objectives.
- Conduct scientific program planning, execution, and management across a broad spectrum of scientific disciplines and program offices; and communicate research interests and priorities to the scientific community.
- Assure rigorous external merit review of research proposals, selection of appropriate peer review experts, development of award recommendations informed by peer review, and regular evaluation of research programs. SC program managers typically manage over 6,000 laboratory, university, non-profit and private industry proposals and receive a total of 5,000 to 6,000 new proposal (peer) reviews and renewals annually.
- Provide oversight of design, construction, and operation of large-scale scientific user facilities at laboratories and universities that support approximately 26,500 users.
- Provide oversight and management of the Science Laboratories Infrastructure program and the maintenance and operational integrity of 10 SC laboratories.
- Provide policy and strategic management in the areas of information technology, grants and contracts, and budget for the SC enterprise.

Site Office Federal Workforce Duties:

SC Site Office personnel are Federal staff charged with maintaining the business and management infrastructure necessary to support the scientific mission of 10 SC national laboratories. This includes conducting day-to-day business transactions of contract management activities, approvals to operate hazardous facilities, safety and security oversight, leases, property transfers, sub-contracts above defined thresholds, sub-awards, and activity approvals required by laws, regulations, and DOE policy. As part of this, the Site Office personnel:

- Maintain a comprehensive contract management program to assure contractual mechanisms supporting nearly $4 billion per year of mission work, performed by SC contractors at 10 national laboratories, are effectively managed consistent with guidelines and regulations.
- Provide technical staff to evaluate complex integrated laboratory activities including nuclear, radiological, and other complex hazards.
- Provide Federal project directors to facilitate execution of line item and other construction projects.

Integrated Support Center (ISC) Federal Workforce Duties

The ISC, co-located at the Chicago and Oak Ridge Offices, provides the backbone for the business infrastructure supporting the entire SC enterprise including legal and technical support; financial management; grant and contract processing; safety, security, and health management; labor relations, intellectual property and patent management; environmental compliance; facility infrastructure operations and maintenance; and information systems development and support. As part of this, the ISC:

- Serves as a legal DOE allottee that manages multi-appropriation, multi-program allotments for all SC national laboratories with responsibility for over 90% of SC funds; and
- Provides support to SC and other DOE programs for solicitations and funding opportunity announcements, as well as the negotiation, award, administration, and closeout of contracts and financial assistance awards (grants) using certified contracting officers and professional acquisition staff.

Office of Scientific and Technical Information (OSTI) Federal Workforce Duties:

OSTI fulfills the Department's legislative mandate to provide public access to the unclassified results of DOE's research program as well as the White House Open Government Directive to encourage collaboration and increase transparency (http://energy.gov/open). OSTI's collection from the mid-1990s to date is available entirely on-line. In FY 2011, OSTI served over 250 million web efficient steward that utilizes taxpayer dollars for maximum national benefit.

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- Collects, protects and provides secure access to DOE's classified research outcomes. OSTI works closely with National Nuclear Security Administration laboratories and facilities to collect classified R&D information and to provide secure access through the Enterprise Secure Network.
- Has built, on behalf of DOE, broad collaborations within the United States and internationally to enable a single point of access to nearly 400 million pages of scientific information.

Program Milestones

- *Voluntary Early Retirement Authority/Voluntary Separation Incentive Payments (VERA/VSIP).* Currently, 247 SC employees (25%) are eligible for voluntary retirement by the end of FY 2012. In early FY 2012, as part of cost reduction and long term strategies to continuously provide an appropriate mix of employee skills, experience, and institutional knowledge, SC was given authority to offer VERA/VSIP to eligible employees in selected job series in OSTI and Field Offices. Both organizations require systems and processes that respond quickly and adapt to the rapidly-changing science and technology environment in which they operate. To achieve this adaptability, OSTI and Field Offices plan a refinement of their respective organizational units, positions, and functions.

Major Programmatic Shifts or Changes

- The overall increase of $17,551,000, or 9.5% from FY 2012, will provide an increase of 48 FTEs and maintain essential research operations at the FY 2011 operating level. The FY 2013 request supports a total FTE level of 1,048, backfill hiring for essential SC positions, controlled retention strategies, and targeted recruitment efforts based on contemporary skill requirements.

  SC has operated under a hiring freeze throughout FY 2011 and also has reduced expenses for travel, support services, and other related costs, which resulted in available carryover funding to sustain essential operations during FY 2012.

  The ongoing need for highly skilled Federal scientific program and project managers requires a PD budget that is congruent with SC mission requirements. From FY 2006 to FY 2012, total SC funding grew at an annualized rate of 5.0%; in contrast, PD funding increased at an annualized rate of 2.5% for the same timeframe. The FY 2013 Request reduces this gap and maintains research oversight and operations at an efficient level.
- On August 15, 2011, the Secretary of Energy approved organizational changes for the Oak Ridge Office to provide direct programmatic oversight and authority for the Office of Science at the Oak Ridge National Laboratory (ORNL). In addition, the Offices of Environmental Management and Nuclear Energy located at Oak Ridge now report directly to their respective HQ Offices. The reorganization provides clear lines of accountability and mission delivery from the program sponsor to the line, eliminates a layer of management, removes duplication, and drives decision making to the lowest practical level in the organization. As a part of this reorganization, several functions (equating to 13 full time equivalent positions) are realigned from the Oak Ridge Office to the ORNL Site Office where they have historically provided support. This realignment provides the ORNL Site Office Manager direct oversight and accountability for the performance of these critical national laboratory functions. Implementation of the approved reorganization is pending completion of impact and implementation negotiations with the local union, which commenced on November 30, 2011. Interactions with local government and Congressional representatives occurred routinely during development of the organizational changes as well as upon approval.
- *President's Council of Advisors on Science and Technology (PCAST).* Per Executive Order 13539, as amended December 19, 2011, "The Department of Energy shall provide such funding and administrative and technical support as the PCAST may require." In FY 2013, on behalf of DOE, SC will assume functional responsibility and administrative management for PCAST activities. As an advisory group to the President and Executive Office of the President, PCAST membership includes the nation's leading scientists and engineers who make policy recommendations in the many areas where

understanding of science, technology, and innovation is key to strengthening our economy and forming policy. PCAST was previously administered by the Office of Science and Technology Policy (OSTP).

Explanation of Funding and Program Changes

(Dollars in Thousands)

	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Salaries and Benefits	137,906	149,757	+11,851

The FY 2013 request for 1,048 FTEs, supports essential operations across the SC complex, and includes 48 FTEs above the FY 2012 ceiling for scientific oversight, project management, and operations support associated with science program portfolio management.

Salaries and Benefits represent 73.9% of the FY 2013 PD budget. FY 2013 is an 8.6% increase from FY 2012 and includes support for expenses such as increases in health coverage costs and employee-driven retirement allocation increases in the Federal Employees Retirement System.

Travel	3,361	3,361	0

Staff travel is required to ensure scientific management, compliance oversight, and external review of research funding across all SC programs since SC senior program managers are not co-located with grantees or on-site at all national laboratories. Travel is also required for facility visits where the use of electronic telecommunications is not practical for mandated on-site inspections and operations reviews.

SC Federal Advisory Committee travel is supported which includes representatives from universities, national laboratories, and industry representing a diverse balance of disciplines, professional experience, and geography. Each of the six advisory committees meets three to four times annually and provides valuable, independent advice to the Department regarding the complex scientific and technical issues that arise in the planning, management, and implementation of SC programs.

Travel represents 1.7% of the PD budget. FY 2013 is sustained at the FY 2012 level.

	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
	(Dollars in Thousands)		
Support Services	20,127	22,041	+1,914

Essential support for multiple levels of technical expertise and business service will be sustained as follows: maintenance, operation, and cyber security management of SC mission-specific information technology systems and infrastructure as well as SC-corporate Enterprise Architecture and Capital Planning Investment Control management; administration of the Small Business Innovation Research/Small Business Technology Transfer program; grants and contract processing and close-out activities; accessibility to DOE's multi-billion dollar R&D program through eGov information systems managed and administered by OSTI; operations and maintenance of the Searchable Field Work Proposal system to provide HQ and Field organizations a tool to search, evaluate, and monitor legacy and current field work proposals; selected limited routine administrative services including travel processing, and training and education of Federal staff to maintain appropriate certifications; select reports or analyses directed toward improving the effectiveness, efficiency, and economy of services and processes; staffing for 24-hour emergency communications centers, and safeguards and security oversight functions.

Support Services represent 10.9% of the FY 2013 PD budget. This is a 9.5% increase from the FY 2012 level. This maintains essential information technology infrastructure support and specialized administrative services for unique needs associated with science program initiatives.

Other Related Expenses	23,606	27,392	+3,786

Provides the SC contribution to the Department's Working Capital Fund (WCF) for common administrative services at HQ, such as rent and building operations, telecommunications, network connectivity, supplies, printing/graphics, mail, purchase card surveillance and salaries and benefits for Federal staff who administer the WCF. Also included are fixed requirements in the Field Offices not funded through the WCF associated with rent, utilities, and telecommunications, building and grounds maintenance, computer/video maintenance and support, printing and graphics, equipment leases, purchases, and maintenance, as well as, site-wide health care units. Also funded are SC-wide assessments for payroll processing and the Corporate Human Resource Information System.

Other Related Expenses represent 13.5% of the FY 2013 PD budget. This is a 16.0% increase from the FY 2012 level and supports mandatory increases in fixed costs, rent, and other WCF requirements including support of new WCF categories; eGov initiatives, employee health services, and overseas representation.

Total Funding Change, Science Program Direction	185,000	202,551	+17,551

Support Services by Category

	(Dollars in Thousands)		
	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Technical Support			
Feasibility of Design Considerations	25	26	+1
Development of Specifications	674	928	+254
System Review and Reliability Analyses	714	928	+214
Surveys or Reviews of Technical Operations	1,485	1,556	+71
Total, Technical Support	2,898	3,438	+540
Management Support			
Automated Data Processing	9,525	10,334	+809
Training and Education	686	731	+45
Reports and Analyses, Management, and General Administrative Services	7,018	7,538	+520
Total, Management Support	17,229	18,603	+1,374
Total, Support Services	20,127	22,041	+1,914

Other Related Expenses by Category

	(Dollars in Thousands)		
	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Other Related Expenses			
Rent to GSA	729	756	+27
Rent to Others	1,162	1,209	+47
Communications, Utilities, and Miscellaneous	1,780	1,835	+55
Printing and Reproduction	10	11	+1
Other Services	3,501	3,781	+280
Operation and Maintenance of Equipment	671	696	+25
Operation and Maintenance of Facilities	1,466	1,516	+50
Supplies and Materials	874	914	+40
Equipment	4,038	5,432	+1,394
Working Capital Fund	9,375	11,242	+1,867
Total, Other Related Expenses	23,606	27,392	+3,786

Supporting Information

Operating Expenses, Capital Equipment and Construction Summary

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Operating Expenses	202,520	185,000	202,551

Program Overview and Benefits

The Department of Energy's Isotope Program produces and sells radioactive and stable isotopes, byproducts, surplus materials, and related isotope services world-wide, and operates under a revolving fund established by the 1990 Energy and Water Appropriations Act (Public Law 101–101), as modified by Public Law 103–316. The combination of an annual direct appropriation and collections from isotope sales are deposited in the Isotope Production and Distribution Program Fund, the revolving fund. This revolving fund allows continuous and smooth operations of isotope production, sales, and distribution independent of the federal budget cycle. The fund's revenues and expenses are audited annually.

The Program's appropriation is received via the Office of Science's Nuclear Physics program. Appropriated funds are used to support the core scientists and engineers needed to carry out the Isotope Program and to operate and maintain isotope facilities to assure reliable production. In addition, the appropriation provides support for R&D activities associated with the development of new production and processing techniques for isotopes, operations support for the production of research isotopes, and support for the training of new personnel in isotope production. Each of the sites' production expenses for processing and distributing isotopes is offset by revenue generated from sales. The Isotope Program cannot be sustained on revenues alone; it requires a combination of appropriated funds and revenue from sales to maintain its viability. Of the total resources in the revolving fund, about 75 percent is used for operations, maintenance, isotope production, and R&D for new isotope production techniques, with roughly 25 percent available for process improvements, unanticipated changes in volume, and purchases of small capital equipment, such as assay equipment and shipping containers needed to ensure on-time deliveries.

The Department has supplied isotopes and related services for more than 50 years to medical institutions, universities, research organizations, and industry. Isotopes are also provided to many Federal agencies, including the National Institutes of Health and its grantees, the Environmental Protection Agency, and the Department of Homeland Security. As the range of available isotopes and the recognized uses for them increased, new or improved isotope products contributed to progress in medical research and treatment, new industrial processes, and scientific investigation. Substantial national and international scientific, medical, and research infrastructure has relied upon the use of isotopes and is strongly dependent on the Department's products and services. Isotopes are now used for hundreds of applications that benefit society every day such as cardiac imaging, cancer therapy, smoke detectors, neutron detectors, explosives detection, oil exploration, and tracers for climate related research. For example, radioisotopes are used in the diagnosis or treatment of about one of every three hospital patients[a]. Each day, over 40,000 medical patients receive nuclear medicine imaging and therapeutic procedures in the United States[b]. Such nuclear procedures are among the safest and most effective diagnostic tests available. Isotopes enhance patient care by avoiding exploratory surgery and similar procedures. For example, the use of Positron Emission Tomography-based myocardial perfusion imaging in emergency room chest pain centers can reduce the duration of stay from 23 hours to 1-2 hours compared to conventional protocols[c]. Adequate supplies of medical and research isotopes are essential to the Nation's health care system and to basic research and industrial applications that contribute to national economic competitiveness. Isotope uses in homeland security applications are also increasing and include portal monitors used to find radiological material, imaging systems used to find densely shielded material, and systems to detect explosives, biological and chemical weapons, and narcotics.

Isotopes are primarily produced and processed at three facilities, which are stewarded by the Isotope Program: the Isotope Production Facility (IPF) at Los Alamos National Laboratory, the Brookhaven Linac Isotope Producer (BLIP) at Brookhaven National Laboratory, and processing facilities at Oak Ridge National Laboratory (ORNL). Accelerator production capabilities are provided

[a] http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/med-use-radactiv-mat-fs.html
[b] http://interactive.snm.org/docs/whatisnucmed.pdf
[c] http://www.positron.com/?page_id=437

by IPF and BLIP which supply isotopes such as strontium-82 and germanium-68 to serve the Nation's health care needs and other isotopes to researchers in a wide variety of fields. Reactor production capability is provided by the High Flux Isotope Reactor (HFIR), which has the highest neutron flux available for isotope production in the U.S. and presently produces isotopes such as californium-252, berkelium-249, nickel-63, and selenium-75 for the Isotope Program. In addition, the Isotope Program manages cobalt-60 production at the Advanced Test Reactor at the Idaho National Laboratory. It will expand production activities at the reactor to produce radiosotopes such as gadolinium-153 and short-lived radioisotopes, making use of the recently installed target shuttle system that allows insertion and removal of isotope production targets while the reactor is operating. At the Pacific Northwest National Laboratory (PNNL), the Isotope Program will continue to distribute strontium-90, a byproduct material of past weapons programs, and has processed byproduct material to recover actinium-227, which will now be used to provide radium-223 for medical research. The Isotope Program is increasing productivity by broadening the suite of production facilities to include university accelerator and reactor facilities which can provide cost-effective and unique production capabilities; these include the Washington University, the University of California at Davis, and the Missouri University Research Reactor.

The resources available in the revolving fund in FY 2011 totaled $48.5 million. This consisted of $19.7 million from the FY 2011 direct Nuclear Physics appropriation and collections of $28.8 million, which are used to cover expenses, support research into alternative production and processing techniques, and develop new production capabilities. Collections increase or decrease depending on customer demand, production efficiencies, and the availability of facilities. The collections in FY 2011 represented an increase relative to FY 2010 due to an increase in sales and production of californium-252, selenium-75, and strontium-82. Californium-252 has a variety of industrial and medical applications, selenium-75 is used as a radiography source, and strontium-82 has gained world-wide acceptance for use in heart imaging which has resulted in increased sales over the last several years. Effective management of the Isotope Program requires constant diligence as factors which influence the program are dynamic by their nature. The revolving fund helps to mitigate impacts from what can be significant and often unanticipated fluctuations in sales.

In FY 2011, the Isotope Program served over 150 customers including major pharmaceutical companies, industrial users, and approximately 100 researchers at hospitals, national laboratories, other Federal agencies, universities, and private companies. There continues to be about ten high-volume and moderately priced isotopes among the many produced by the Program; the remaining isotopes are low-volume research isotopes and thus more expensive to produce. Progress has been made in the past year in evaluating the pricing of isotopes in an effort to make research isotopes more affordable; these efforts are continuing. Commercial isotopes will continue to be priced to recover full cost. Research isotopes are provided at reduced prices that provide compensation to the government while encouraging research and development. For example, expenses supported with appropriated funds are not charged to the researcher, reducing the price of the isotope. Improved communication with the user community and federal agencies has improved the ability to forecast demand of needed isotopes, which positions the Isotope Program to better meet the projected needs of the community, resulting in a more reliable supply of research isotopes. A Federal workshop in FY 2012 initiated by the Isotope Program will provide further valuable information to assist the Isotope Program in optimizing utilization of its resources to assure the greatest availability of isotopes.

Of the isotopes produced and sold by the Isotope Program, the majority are for medical research. A total of 460 shipments were made in FY 2011. Roughly a third of these shipments were to foreign countries with the remainder sold domestically, including 10% or less to other Federal agencies. Customer satisfaction with product specifications continues to be high; over 98% of products and services provided met the terms of the contract/sales order in FY 2011.

For FY 2013 and the future, the Department foresees more than moderate growth in isotope demand, coupled with the possible need for new isotope products for homeland security, medicine, and industry. In order to satisfy the needs of its customers, the program seeks to meet supply requirements for year-round availability of isotopes for scientific and medical research and, in particular, for human clinical trials. The program's production capability may be called upon for initial ramp-up of production of major new isotope products until market forces bring in private producers that are willing to invest and produce the needed isotopes.

Program Accomplishments

The Isotope Development and Production for Research and Applications (IDPRA) program made recent advances in several areas of national isotope needs. One such advance was the production in FY 2011 of nickel-63 of much higher purity than previously available. Nickel-63 is used in national security applications such as explosives detection systems.

A second advance was the development and implementation, in collaboration with NNSA, of a plan to avert a potential critical shortage of the isotope americium-241. To initiate this plan, the Isotope Program has begun preparations for americium-241 production at the Los Alamos National Laboratory. Americium-241 is used commercially in smoke detectors and in neutron sources for oil and gas exploration.

Advanced Research Projects Agency-Energy

Advanced Research Projects Agency-Energy

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The Department of Energy's Congressional Budget justification is available on the Office of Chief Financial Officer, Office of Budget homepage at http://www.cfo.doe.gov/crorg/cf30.htm.

Advanced Research Projects Agency - Energy (ARPA-E)

Proposed Appropriation Language

For necessary expenses in carrying out the activities authorized by section 5012 of the America COMPETES Act (Public Law 110-69), as amended, $350,000,000, to remain available until expended: Provided, That $25,000,000 shall be available until September 30, 2014 for program direction.

Explanation of Change

The Department request of $350,000,000 FY 2013 for ARPA-E projects, a 27 percent increase over the enacted FY 2012 level, underscores the Administration's commitment to invest in innovation. The increase in funding will enable ARPA-E to fund more projects that could lead to transformational energy technologies.

Advanced Research Projects Agency - Energy (ARPA-E)

Overview
Appropriation Summary by Program

(Dollars in Thousands)

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Advanced Research Projects Agency – Energy (ARPA-E)			
Projects	165,640	255,000	325,000
Program Direction	14,000	20,000	25,000
Total, Advanced Research Projects Agency – Energy (ARPA-E)	179,640	275,000	350,000

Office Overview and Accomplishments

ARPA-E's mission is to support energy technology innovations that will enhance the economic and energy security of the United States through the development of transformational technologies that reduce America's dependence on energy imports; reduce U.S. energy related emissions; improve energy efficiency across all sectors of the U.S. economy; and ensure the U.S. maintains a technological lead in the development and deployment of advanced energy technologies. ARPA-E focuses exclusively on high-impact innovations, translating science into breakthrough technologies that promise genuine transformation in the ways we generate, store, and utilize energy.

ARPA-E employs a thorough merit review process to select projects based on their potential impact on ARPA-E's mission and their innovative technical approaches and project teams. ARPA-E funds technologies that are not being supported by other parts of DOE or the private sector because of technical and financial uncertainty. ARPA-E coordinates closely with other DOE programs, the rest of the federal government, academia, and the private sector to identity "white space" where others are not making investments in innovation but that would be appropriate for ARPA-E's support.

If just a fraction of the breakthrough technologies funded by ARPA-E are successful in reaching the marketplace they could render the prevailing technologies obsolete. Such innovations can benefit the United States through the creation of new industries and jobs, reductions in energy costs and increases in energy efficiency, and accelerating progress towards achieving the Administration's energy and climate goals. Through its work, ARPA-E contributes to the achievement of the Department's strategic goal, "**Transform our Energy Systems:** Catalyze the timely, material, and efficient transformation of the nation's energy system and secure U.S. leadership in clean energy technologies."

The role of ARPA-E is to translate science into innovative breakthrough technologies that no one else is pursuing, i.e. technologies that are defined by new learning curves. (see Figure). By definition, these involve new, innovative, but potentially riskier approaches than traditional or current learning curves. But they also offer the prospects of transformational and disruptive technologies by dramatically reducing their costs-to-performance ratio. ARPA-E's goal is to support these approaches and to showcase them to enable further development through either the private sector or the federal government. Some of these approaches will potentially fail, but the ones that succeed could transform the energy sector and make today's approaches obsolete. It is difficult to know which ones will fail or succeed, but all failures will provide opportunities to learn and could become the basis for further innovation. Such a process would help the U.S. embark on a path of continuous innovation and scaling and enhance US technological leadership in a globally competitive world.

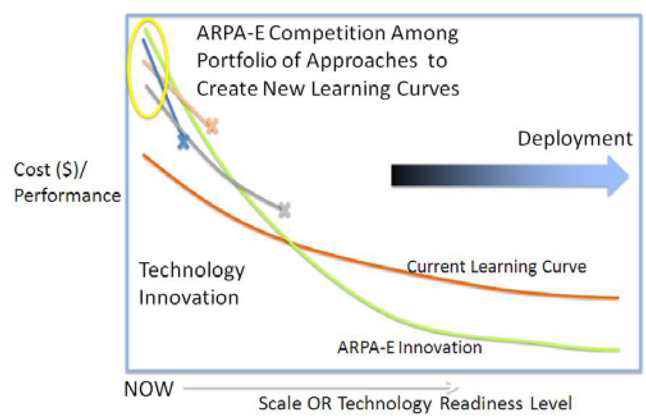


Figure 1: ARPA-E Innovations Create New Learning Curves

R&D Coordination across DOE

ARPA-E actively coordinates with other DOE programs and Federal agencies and others in the technical community in order to ensure that its projects do not overlap with other programs at DOE or elsewhere, but instead complement them in multiple ways. ARPA-E engages these stakeholders when it conducts workshops, establishes technical metrics for potential funding solicitations and reviews applications.

ARPA-E works in close coordination with program offices on its "borders" – DOE's basic science and applied research programs – to avoid duplicative research and ensure a balanced research portfolio across the DOE. ARPA-E utilizes the close coordination and collaboration to identify gaps in research portfolios ("white space"). This coordination serves to inform all parties of each other's ongoing research activities and to facilitate the transition of successful ARPA-E projects to other DOE programs or elsewhere.

An important part of ARPA-E's coordination within DOE is the program's Panel of Senior Technical Advisors (PASTA). PASTA consists of Assistant Secretaries (or their designee) of relevant applied energy offices as well as the heads of all the relevant offices in the Office of Science. The purpose of PASTA is to coordinate and leverage each of its programs and also to ensure that ARPA-E provides unique value within the DOE. In addition, the Director of ARPA-E actively coordinates with the Director of the Office of Science as well as the Under Secretaries for Energy and Science.

Program Accomplishments and Milestones

In FY 2011, ARPA-E achieved significant accomplishments or milestones in program management and program development. Such accomplishments include:

1) *Follow-on funding:* Less than two years after ARPA-E's initial investment in 121 projects of $365 million, eleven of those projects have garnered over $200 million in follow-on funding (not including required cost share) to support the further development and deployment of the ARPA-E-funded technologies. Awardees have cited ARPA-E's initial funding and active program management as critical factors in their overcoming key technical barriers ahead of schedule which helped spur follow-on funding. While ARPA-E projects have yet to show ultimate success as deployed technologies, a possibility that may be 10-15 years away, ARPA-E considers follow-on funding to be an early indicator of success and highlights how small but strategic investments by the federal government could pay big dividends in the not-too-distant future.

2) *Demonstrated success of active program management approach:* All of ARPA-E's awards are cooperative agreements, enabling the program to practice active program management on all of its projects. Since ARPA-E has been funding projects for just over two years, only one project has completed its funding to date. That project successfully met its technical milestones and the cognizant Program Director held a project wrap up meeting to capture what was learned and to begin to establish best practices. ARPA-E also has not hesitated to cancel projects that are not meeting their goals. ARPA-E has ended six projects funded through the Recovery Act to date and, per the statutory requirement, has returned the remaining funding from those projects to the Treasury. It is important to understand that we will learn not only from projects that succeed but also from projects that "fail." ARPA-E will continue to actively manage and monitor projects, and will continue to cancel projects that are not meeting their technical milestones and metrics.

3) *New projects*: ARPA-E issued its fourth round of Funding Opportunity Announcements (FOAs) and announced 60 cutting-edge research projects aimed at dramatically improving how the U.S. produces and uses energy. Funded at over $150 million in total, the new ARPA-E projects focus on accelerating innovations in clean energy technology. This is accomplished by increasing America's competitiveness in rare earth alternatives and by supporting breakthroughs in biofuels, thermal storage, grid controls, and solar power electronics. The projects selected are located in 25 states, with 50% of projects led by universities, 23% by small businesses, 12% by large businesses, 13% by national labs, and 2% by non-profits.

In FY 2012 ARPA-E held, or plans to hold, up to seven workshops and events on technical topics that may lead to future FOAs. Also, in FY 2012 ARPA-E plans to issue FOAs in the following areas:

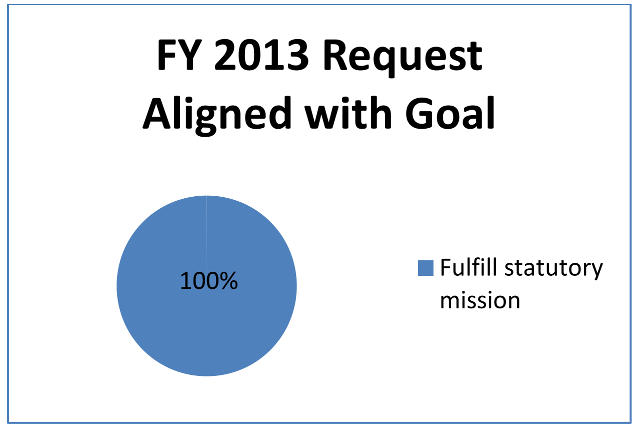
1. Hybrid Energy Storage Modules (HESM)
2. Natural gas conversion and/or compression/storage for transportation systems
3. SBIR/STTR
4. Open FOA

These FY 2012 activities are detailed in the ARPA-E Projects section that follows.

Alignment to Strategic Plan

The Department's May 2011 Strategic Plan outlines the primary objective to which ARPA-E aligns its activities: Discover the New Solutions We Need. The Strategic Plan identifies four targeted outcomes to achieving these objectives, and ARPA-E is responsible for supporting Strategic Plan outcomes through its budget request. The targeted outcomes are:

- Catalyze by FY 2012 the development of transformative and potentially disruptive energy technologies;
- Drive the transition of high-impact energy innovations toward market adoption;
- Contribute to the advancement of U.S. leadership and global competitiveness in energy innovation; and
- Build itself as an innovative, highly effective, and sustainable organization.



Explanation of Changes

The Department requests $350,000,000 in FY 2013 for ARPA-E, which is a 27% increase over the current FY 2012 level. This increase underscores the Administration's commitment to invest in innovation. The increase in funding will enable ARPA-E to fund more projects that could lead to game-changing, transformative technologies.

In FY 2013, ARPA-E is placing a particular priority on Transportation Systems, including advanced manufacturing for this sector and vehicles research and development. ARPA-E aims to create a diverse portfolio of technological options that would promote the efficient use of energy for transportation.

Goal/Program Alignment Summary

	GOAL 1: Fulfill statutory mission
ARPA-E Projects	100%
Program Direction	100%
Total, ARPA-E	100%

Strategic Plan and Performance Measures

STRATEGIC GOAL: TRANSFORMING OUR ENERGY SYSTEMS; CATALYZE THE TIMELY, MATERIAL, AND ECONOMIC TRANSFORMATION OF THE NATION'S ENERGY SYSTEM AND SECURE U.S. LEADERSHIP IN CLEAN ENERGY TECHNOLOGIES.		
OBJECTIVE: DISCOVERING THE NEW SOLUTIONS WE NEED		
TARGETED OUTCOME: CONTRIBUTE TO THE ADVANCEMENT OF U.S. LEADERSHIP AND GLOBAL COMPETITIVENESS IN ENERGY INNOVATION		
FY11 ANNUAL MEASURE #1: <u>CUMULATIVE PERCENTAGE OF FOLLOW ON FUNDING FROM OTHER FEDERAL (NOT ARPA-E) AND PRIVATE ORGANIZATIONS AFTER HAVING RECEIVED ARPA-E DIRECT FUNDING</u>		
	Target	Actual/ Met or Not Met
Budget Year	2013: 20%	N/A
Current Year	2012: 15%	N/A
Prior Year	2011: 10%	Actual: 54% / Met
Analysis	Provides an early indicator of success that ARPA-E has selected projects that show the potential to make progress towards achieving the agency's mission.	
ANNUAL MEASURE #2: <u>CUMULATIVE PERCENTAGE OF AWARD FUNDING COMMITTED 45 DAYS AFTER FUNDING OPPORTUNITY ANNOUNCEMENT (FOA) AWARD ANNOUNCEMENTS.</u>		
	Target	Actual/ Met or Not Met
Budget Year	2013: 70%	N/A
Current Year	2012: 70%	N/A
Prior Year	2011: 70%	Actual: 75% / Met
Analysis	Provides a measureable metric for the speed and efficiency of ARPA-E's procurement process.	

Small Business Innovation Research/ Small Business Technology Transfer (SBIR/STTR)

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
ARPA-E SBIR/STTR	5,030	8,113	10,675
Total, ARPA-E SBIR/STTR	5,030	8,113	10,675

ARPA-E will establish an innovative SBIR/STTR program that is separate from the DOE-wide SBIR/STTR program. The ARPA-E SBIR/STTR program will employ the review, contracting, funding, and organizational reforms implemented successfully by ARPA-E. For example, ARPA-E will use its user-friendly online application portal, ARPA-E eXCHANGE, to receive and evaluate proposals. ARPA-E will reduce the average contracting period (from selection to award) to two months. Additionally, ARPA-E has undertaken a comprehensive survey of other Federal agencies' SBIR/STTR programs and has identified a number of best practices and innovations that may be used for its SBIR/STTR program.

Advanced Research Projects Agency - Energy (ARPA-E)
Funding by Site by Program

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Washington Headquarters			
Advanced Research Projects Agency – Energy (ARPA-E)	179,640	275,000	350,000
Total, Washington Headquarters	179,640	275,000	350,000
Total, Advanced Research Projects Agency – Energy (ARPA-E)	179,640	275,000	350,000

ARPA-E Projects
Funding Profile by Subprogram and Activities

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
ARPA-E Projects			
Projects	160,610	246,887	314,325
SBIR/STTR	5,030	8,113	10,675
Total, ARPA-E Projects	165,640	255,000	325,000

Comparable Funding Profile by Subprogram and Activities

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
ARPA-E Projects			
Transportation Systems[1]	60,610	142,887	184,325
Stationary Power Systems[1]	100,000	104,000	130,000
SBIR/STTR	5,030	8,113	10,675
Total, ARPA-E Projects	165,640	255,000	325,000

[1] Because the Transportation Systems and Stationary Power Systems thrusts are new for the FY 2013 Congressional Budget, a comparable funding profile is provided to show estimates for how the FY 2011 and FY 2012 funds are split between the Transportation Systems or Stationary Power Systems thrusts. The FY 2012 Enacted figure includes estimate as to how funding from the planned Open FOA will be distributed across the thrusts.

Public Law Authorizations

Public Law 95-91, "Department of Energy Organization Act" (1977)
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

ARPA-E Projects will identify and promote early-stage research and development projects with the promise to make revolutionary advances in applications of breakthrough energy science, translate scientific discoveries and cutting-edge inventions into technological innovations, and accelerate transformational technological advances in areas that industry by itself will not support because of technical and financial risk and uncertainty.

ARPA-E programs generally fall into two categories:

- New Areas of Science and Technology—for example, the goal of ARPA-E's current Electrofuels program is to produce biofuels in a new way from non-photosynthetic autotrophic bacteria. This first-of-kind program is emblematic of ARPA-E and, if successful, could create an entirely new industry.
- New Generation Technology—for example, ARPA-E's current program called Batteries for Electrical Energy Storage in Transportation, or BEEST. While DOE's applied energy activities and most outside R&D is focused on lithium batteries, ARPA-E is looking for other battery chemistries that, if successful, would yield batteries that are less expensive and provide longer range and storage capabilities than today's approaches.

ARPA-E continues to improve its internal strategic vision for the future direction of the agency. Reflecting this internal strategic thinking on the focus of future projects, ARPA-E has moved to incorporate a project management model hierarchy of thrust-portfolio-program-project. ARPA-E will have two primary thrusts: Transportation Systems and Stationary Power Systems. The two broad thematic strategic thrusts and their attendant portfolios and programs are explored more deeply in the Transportation Systems and Stationary Power Systems sections that follow.

Program Accomplishments and Milestones

In FY 2011, ARPA-E issued Funding Opportunity Announcements (FOAs) totaling $130 million to develop five new program areas that could spark critical breakthrough technologies and secure America's energy future.

- Plants Engineered To Replace Oil (PETRO): Technologies that optimize the biochemical processes of energy capture and conversion to develop robust, farm-ready crops that deliver more energy per acre with less processing prior to the pump. If successful, PETRO will create biofuels for half their current cost potentially making them cost-competitive with oil-based fuels.
- High Energy Advanced Thermal Storage (HEATS): Revolutionary cost-effective thermal energy storage technologies in three focus areas: 1) high temperature storage systems to deliver solar electricity more efficiently around the clock and allow nuclear and fossil base load resources the flexibility to meet peak demand, 2) fuel produced from the sun's heat, and 3) HVAC systems that use thermal storage to improve the driving range of electric vehicles by up to 40 percent.
- Rare Earth Alternatives in Critical Technologies (REACT): Early-stage technology alternatives that reduce or eliminate the dependence on rare earth materials by developing substitutes in two key areas: electric vehicle motors and wind generators.
- Green Electricity Network Integration (GENI): Innovative grid control software and high-voltage hardware, specifically: 1) controls able to manage 10 times more sporadically available wind and solar electricity than currently on the grid, and 2) resilient power flow control hardware - or the energy equivalent of an internet router - to enable significantly more electricity through the existing network of transmission lines.
- Solar Agile Delivery of Electrical Power Technology (Solar ADEPT): The DOE SunShot Initiative leverages strengths across DOE to reduce the total cost of utility-scale solar systems by 75 percent by the end of the decade. If successful, this collaboration would deliver solar electricity at roughly 6 cents a kilowatt hour. ARPA-E's portion of the collaboration is the Solar ADEPT program, which focuses on integrating advanced power electronics into solar panels and solar farms to extract and deliver energy more efficiently.

In FY 2012 ARPA-E held, or plans to hold, workshops and events on the following technical topics:

1. Tool Development for Transformational Biotechnology Advances Workshop (October 2011)
2. Soft Magnetic Materials Review (December 2011)
3. Natural Gas Conversion Technologies Workshop (January 2012)
4. Natural Gas Vehicle Technologies Workshop (January 2012)
5. Large-Scale Behavioral Analytics in Personal Transportation & Motor Fuel Purchases Workshop (February 2012)
6. Advanced Inductance Motors Seminar (March 2012)
7. Power Grid Gaming Workshop (not yet scheduled)

In FY 2012 ARPA-E plans to issue the following FOAs:

1. Hybrid Energy Storage Modules (HESM) that couple and optimize attributes of different energy storage technologies with real-time sensory, analysis, and control techniques to increase efficiency, capacity utilization, reliability, and lifetime across transportation and stationary applications. This FOA was developed jointly with the Department of Defense.
2. Natural gas to explore unique approaches for the conversion of natural gas into energy-dense, infrastructure-compatible liquid fuels for transportation, and/or novel and low-cost natural gas compression and storage technologies enabling widespread adoption of natural gas fueled vehicles.
3. SBIR/STTR
4. Open FOA in March 2012. This will be ARPA-E's second Open FOA and, similar to ARPA-E's initial FOA from April 2009, the FY 2012 Open FOA will be open to any transformational energy technology.

Milestone	**Date**
Make decisions on program goals,	December

activities and funding based on annual review, contingent upon appropriations.	2011
Hire new Program Directors who will be able to lead FOAs focused on transportation.	January 2012
Continue active program management of existing transportation projects.	Ongoing

Explanation of Changes

The Department requests $325 million in FY 2013 for ARPA-E projects, which is a 27 percent increase over the enacted FY 2012 level. This increase underscores the Administration's commitment to invest in innovation. The increase in funding will enable ARPA-E to fund more projects that could lead to game-changing, transformative technologies.

In FY 2013, ARPA-E is placing a particular priority on Transportation Systems, including advanced manufacturing and vehicles research and development. ARPA-E aims to create a diverse portfolio of technological options that would reduce our dependence on foreign energy imports, and instead promote the efficient use of domestic sources of energy for transportation. This focus may include another round of funding in the Electrofuels program, taking a new look at transformational biofuels approaches, and investing in innovative approaches to natural gas conversion and/or compression/storage for transportation systems. ARPA-E plans to also further explore game-changing battery technologies for plug-in hybrid electric vehicles (PHEVs) and electric vehicles (EVs).

Program Planning and Management

ARPA-E exists to aid the development and accelerate the deployment of transformational and disruptive energy technologies—technologies that hold the potential to radically shift the nation's energy sector. ARPA-E selects potential investment areas by considering the science and technology landscape, the market landscape, and the regulatory landscape. ARPA-E will invest in technology development only in instances where circumstances in each of these areas are aligned to enable transformative, breakthrough discoveries that have the potential to then be brought to market scale. ARPA-E programs are created through a detailed process that begins with a thorough vetting of a particular technology concept. Figure 2 shows the full life cycle of an ARPA-E program (Envision, Engage, Evaluate, Establish, and Execute) from program conception through transition toward market adoption (See Figure).

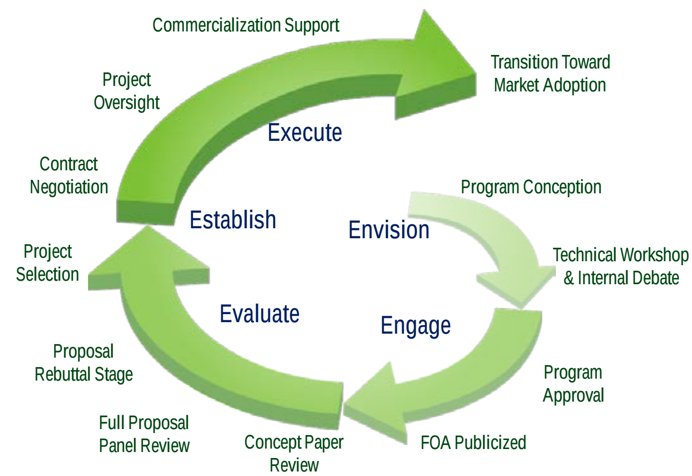


Figure 2: ARPA-E Technology Acceleration Approach

Technical flexibility and empowerment of Program Directors are key aspects of ARPA-E. Before starting a program ARPA-E will do in-depth research, market studies, have discussions with experts from the technical community, and hold a technical workshop to determine if ARPA-E should start a program in an area of interest.

By bringing together experts from across disciplines in science, technology, and business, ARPA-E breaks down silos between disciplines. This cross-disciplinary inquiry bridges the gap between basic and applied research and development. ARPA-E workshops bring together the leading experts to identify technical challenges and opportunities that connect science to technology and markets—linking knowledge of what science is capable of to what technology can achieve and what the market needs.

ARPA-E is vigilant in its researching, investigating, and coordinating to ensure the agency does not fund any discrete technical idea that is being explored by the private sector or by a different program within DOE. ARPA-E Program Directors will coordinate with other DOE offices and federal agencies, as well as groups outside of government, to identify untapped opportunities.

Before issuing a Funding Opportunity Announcement (FOA) in any particular technology area, ARPA-E studies that area in depth. ARPA-E consults closely with other DOE offices and programs to avoid any duplication or redundancy. ARPA-E engages members of other DOE offices in ARPA-E workshops, defining the FOAs, and the proposal review process. Not every workshop necessarily leads to a program/FOA, but every program/FOA follows from a workshop.

ARPA-E undertook an extensive planning process to create the programs in both its thrusts. The detailed program creation process began with a "deep dive" – a process of thoroughly exploring the aspects of the energy challenges related to transportation – to identify potential topics for program development. From there, ARPA-E Program Directors held technical workshops to gather input from the world's leading experts about current state-of-the-art technologies and new technological opportunities that lie on the horizon.

ARPA-E has hosted or co-hosted the following five workshops related to transportation:

- Electrical Energy Storage for Vehicles
- Novel Approaches to Direct Solar Fuels Workshop
- Applied Biotechnology for Transportation Fuels: Meeting Today's Energy Needs by Maximizing Photon Capture
- ARPA-E Critical Materials Technology Workshop
- Tool Development for Transformational Biotechnology Advances

For the Stationary Power Systems thrust, ARPA-E has hosted or co-hosted twelve workshops:

- Grid Scale Energy Storage
- Novel Approaches to Direct Solar Fuels
- Carbon Capture and Conversion
- Advanced Building Energy Technologies
- Energy from Wastewater
- Power Technologies
- $1/W
- Critical Materials Technology
- Small-Scale Distributed Generation
- Hybrid Energy Storage Module
- Power Electronics in Photovoltaic Systems
- Green Electricity Network Integration

From these workshops, ARPA-E announced its fourth round of funding in April 2011, focused on breakthroughs in rare earth mineral alternatives, in biofuels, thermal storage, grid controls, and solar power electronics.

ARPA-E will continue to build on the already strong cooperative relationship with the U.S. Department of Defense to continue to develop advanced clean energy technologies. Advances in innovation are helping to solve our military challenges, protect our troops, and enhance our national security.

<u>Strategic Management</u>

In meeting identified challenges to Transportation Systems, ARPA-E will implement two key strategies to more efficiently and effectively manage the Transportation Systems thrust.

1. ARPA-E will pursue the most promising pathways to increased adoption of alternative liquid fuels production, vehicle electrification, and other technologies with market-oriented performance metrics designed to spur further follow-on funding.
2. ARPA-E's R&D programs will partner with the private sector, national laboratories, other Federal agencies, and universities to develop advanced technologies.

Three external factors present the strongest impacts to the overall achievement of the Transportation Systems thrust strategic goal:

1. Transportation fleets are relatively long-lived assets (with a current average passenger car expected to be on the road for 11 years) and slow adoption rates for new technologies both mean that the energy and efficiency savings can take a long period of time to accrue.
2. Drop-in replacement technologies can offer more immediate impact but research must be mindful of their cost and the time required for testing and certification.
3. Current transportation patterns and associated land-use patterns are historically slow to change.

In meeting the identified challenges to Stationary Power Systems, ARPA-E will implement two key strategies to more efficiently and effectively manage the Stationary Power Systems thrust.

1. ARPA-E will engage the power generation community to help identify and promote the development of transformational, cost-competitive technologies
2. ARPA-E's R&D programs will partner with other DOE Offices and programs, the private sector, national laboratories, other Federal agencies

and universities to develop advanced R&D technologies

Three external factors present the strongest obstacles to the overall achievement of the Stationary Power Systems thrust strategic goal:

1. Components of the stationary power system must operate with extremely high and proven reliability, which can slow the adoption of new technologies.
2. The stationary power system is a highly complex, regulated, and inter-connected operation with many stakeholder requirements to be satisfied prior to technology adoption.
3. Adoption of improved efficiency technologies is dependent of economic and environmental factors beyond the scope of DOE R&D programs.

Major Priorities and Assumptions

ARPA-E's mission is to aid the development of transformational and disruptive energy technologies – technologies that hold the potential to radically shift the nation's energy reality.

Transportation Systems thrust: Specific goals in the outyears include making substantial progress in the areas of:

- Batteries and systems for electric vehicles
- Sustainable and market-competitive transportation fuels from domestic resources
- Information technology related to transportation
- Cost-effective power generation/propulsion systems
- Natural gas conversion and/or compression/storage for transportation systems

Stationary Power Systems thrust: In order to achieve the President's challenge of generating 80% of America's electricity from clean energy sources by 2035, specific goals in the outyears include making substantial progress in the areas of:

- Stationary Power
- Electrical Infrastructure
- End Use Efficiency
- Embedded Efficiency

Program Goals and Funding

ARPA-E has established a goal for its program management, to fulfill its statutory mission of transformational energy research. The goal of ARPA-E shall be:

(A) to enhance the economic and energy security of the United States through the development of energy technologies that result in—

(i) reductions of imports of energy from foreign sources;

(ii) reductions of energy-related emissions, including greenhouse gases; and

(iii) improvement in the energy efficiency of all economic sectors; and

(B) to ensure that the United States maintains a technological lead in developing and deploying advanced energy technologies.

Goal Areas by Subprogram

	Goal Area: Fulfill Statutory Mission
ARPA-E Projects	
Transportation Systems	100%
Stationary Power Systems	100%
Subtotal, ARPA-E Projects	100%

Explanation of Funding AND/OR Program Changes

	(Dollars in Thousands)		
	FY 2012 Enacted	FY 2013 Request	FY 2013 Request vs FY 2012 Enacted
ARPA-E Projects. The FY 2013 request for ARPA-E projects is a 27 percent increase over the enacted FY 2012 level. This increase underscores the Administration's commitment to invest in innovation. The increase in funding will enable ARPA-E to fund more projects that could lead to game-changing, transformative technologies. Reflecting the refinements to the internal strategic thinking on the focus of future projects, ARPA-E has moved to incorporate a project management model hierarchy of thrust-portfolio-program-project. ARPA-E will have two primary thrusts: Transportation Systems and Stationary Power Systems. In FY 2013, ARPA-E is placing a particular priority on Transportation Systems, including advanced manufacturing and vehicles research and development.	255,000	325,000	+70,000
Total, ARPA-E Projects	255,000	325,000	+70,000

Transportation Systems
Comparable Funding Profile by Activity

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
	(Dollars in Thousands)		
Transportation Systems	60,610	142,887	184,325
Total, Transportation Systems	60,610	142,887	184,325

Overview

The ARPA-E Transportation Systems thrust seeks to create a diverse portfolio of technological options that would reduce our dependence on oil, and instead rely on the efficient use of domestic sources of energy for transportation, while also focusing on reducing fuel consumption and energy-related emissions through advances in fuel/propulsion and vehicles.

In 2010, the U.S. consumed 19.2 million barrels of petroleum per day, about 50 percent of which was imported from foreign sources. The U.S. transportation sector represents nearly 70 percent of U.S. petroleum consumption and accounts for roughly 28 percent of U.S. CO_2 emissions. To date, activities at ARPA-E in the transportation sector have focused largely on fuels. ARPA-E will continue to invest in the transportation sector, in both fuels and vehicles.

Some broad goals and benefits of the Transportation Systems thrust include development and batteries and energy storage systems, development of competitively-priced transportation fuels, novels uses of information technology to improve energy efficiency, and unexplored uses of natural gas.

ARPA-E's efforts in the transportation system area seek to diversify fuel choices in the transportation sector away from a nearly exclusive reliance on oil, improve vehicle efficiency, develop and improve alternative transportation technologies.

Explanation of Funding Changes (Comparable)

	FY 2012 Enacted	FY 2013 Request	FY 2013 Request vs FY 2012 Enacted
	(Dollars in Thousands)		
Transportation Systems. Though exact allocations between thrusts will depend on the applications received, ARPA-E anticipates the funding level for the Transportation Systems thrust to be as shown. The increase reflects the priority ARPA-E is placing on Transportation Systems, including advanced manufacturing and vehicles research and development.	142,887	184,325	+41,438
Total, Transportation Systems	142,887	184,325	+41,438

Funding and Activity Schedule

In FY 2013 ARPA-E is placing an increased priority and focus on Transportation Systems, including advanced manufacturing for this sector and vehicles research and development. ARPA-E will continue to invest in the transportation sector, in both alternative domestic sources of sustainable fuels and electrification of vehicles. ARPA-E believes there are critical "white spaces" within the field of transportation systems where neither the private sector nor other areas within the Department are exploring, largely due to the increased-risk early-stage nature of the research and the relative financial uncertainty.

ARPA-E's model seeks to find new and timely opportunities, often soon after they emerge. While the goals of specific FOAs will be informed by technical stakeholder input closer to the announcement of the Funding Opportunities, ARPA-E is planning on investing in the following areas related to transportation systems. ARPA-E plans to renew its investment in Electrofuels, which will select for successful technologies capable of advancing to mid-stage technology readiness pilot scale. ARPA-E will continue to expand support for novel approaches. Future programs would build on the ARPA-E Electrofuels Program, which considers non-photosynthetic autotrophic biological approaches to convert energy resources and carbon dioxide directly into fuel. Successful Electrofuels approaches will be improved to increase energy conversion efficiency and lower cost, subject to rigorous techno-economic analysis to ensure cost-effective deployment, and scale-up to de-risk commercial investment.

Similarly, ARPA-E aims to invest in new approaches to biofuels. ARPA-E will explore what has limited the use of biological system in augmenting energy supplies and how those limitations can be overcome to leverage biology for transformational improvements in energy conversion. This may include developing different approaches to renewable methane, which aims to turn whole biomass into methane; new technologies to lower the cost and improve performance of bioreactors; and, biomanufacturing.

ARPA-E plans to expand its support of electric vehicle technologies. Development of those batteries and systems would allow electric vehicles to have a range of 300-500 miles, and be less expensive than cars based on internal combustion engines. These battery systems may target high energy and power densities by combining batteries and ultracapacitors with lightweight structural packaging materials and appropriate thermal management. The goal would be to overcome "range anxiety" (>300 miles driving range) and simultaneously deliver sufficient power for acceleration. Low-cost, high-efficiency, user-friendly vehicle charging technology would also be targeted, including "fast charging" systems that transfer an order of magnitude more energy into electric vehicles over short durations (5-15 minutes) than current state of the art systems without degrading battery life or adversely impacting the electric grid. While much current investment is focused on vehicle development, ARPA-E will also consider allied technologies required to ensure successful deployment of a mass-market product. In this program, ARPA-E will support game-changing technologies that range from devices to double the minimum range of today's electric cars, to high risk batteries (e.g. lithium-air, lithium-sulfur, and magnesium ion) that could allow a car to travel up to 500-miles on a single charge.

ARPA-E is interested in investing in the development of sustainable and market-competitive transportation fuels using domestic resources such as natural gas or a combination of carbon dioxide and hydrogen. ARPA-E will explore unique approaches for the conversion of natural gas into energy-dense, infrastructure-compatible liquid fuels for transportation. ARPA-E is interested in supporting the exploration of methane conversion protocols, including biological routes through methanotrophic systems, to convert natural gas to gasoline and diesel cleanly and efficiently.

Rare earths are naturally-occurring minerals with unique magnetic properties that are used in many emerging energy technologies. ARPA-E seeks to fund early-stage technology alternatives that reduce or eliminate the dependence on rare earth materials by developing substitutes for electric vehicle motors. This aims to continue and further develop the work being funded under ARPA-E's Rare Earth Alternatives in Critical Technologies (REACT) program.

ARPA-E seeks to fund technology alternatives for several candidate biofuel crops, and this aims to continue and further develop the work being funded under ARPA-E's Plants Engineered To Replace Oil (PETRO) program.

Fiscal Year	Activity	Funding (Dollars in Thousands)
FY 2011	In FY 2011, ARPA-E invested in innovations in: • Technologies that optimize the biochemical processes of energy capture and conversion to develop robust, farm-ready crops that deliver more energy per acre with less processing prior to the pump. • Cost-effective thermal energy storage technologies for HVAC systems that use thermal storage to dramatically improve the driving range of electric vehicles. • Early-stage technology alternatives that reduce or eliminate the dependence on rare earth materials by developing substitutes for electric vehicle motors.	60,610
FY 2012	In FY 2012, ARPA-E is planning on investing in innovations in: • Unique approaches for the conversion of natural gas into energy-dense, infrastructure-compatible liquid fuels for transportation. • Novel and low-cost natural gas compression and storage technologies enabling widespread adoption of natural gas fueled vehicles. • A Broad Funding Opportunity Announcement open to all energy ideas and technologies and focused on applicants who already had well-formed research and development plans for potentially high-impact concepts or new technologies.	142,887 (Estimated pending award selection)
FY 2013	In FY 2013, ARPA-E is planning to invest in innovations in: • Technologies that overcome limitations in traditional biological systems to dramatically increase biofuel production for transportation. • Batteries and systems for electric vehicles that aim to have a range of 300-500 miles while costing less than cars based on internal combustion engines. • Early-stage technology alternatives that reduce or eliminate the dependence on rare earth materials by developing substitutes for electric vehicle motors. • Novel cost-effective power generation or propulsion systems that have significantly higher efficiency than today's internal combustion engines. This will maximize the use of transportation fuels. • Development of sustainable and market-competitive transportation fuels using domestic resources such as natural gas or a combination of carbon dioxide and hydrogen that have 5-10 times less land and water use than that of biomass or algae-based biofuels.	184,325

Stationary Power Systems
Comparable Funding Profile by Subprogram and Activity

(Dollars in Thousands)

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Stationary Power Systems	100,000	104,000	130,000
Total, Stationary Power Systems	100,000	104,000	130,000

Overview

The ARPA-E Stationary Power Systems thrust supports high-impact technologies that are not related to transportation. Some of these fields include: power electronics, solar, wind, osmotic power, smart grid technologies, natural gas, geothermal, and waste heat capture. To accomplish its mission and address the scientific challenges outlined below, ARPA-E's Stationary Power Systems is organized into four portfolios: Stationary Power, Electrical Infrastructure, End Use Efficiency, and Embedded Efficiency.

ARPA-E will continue its mission in this sector to move beyond incremental changes to existing energy technology and to identify those transformational technologies will make current technologies obsolete. ARPA-E is investing in transformational R&D in a number of power generation technologies, and coordinating that investment with the DOE's Office of Science and applied research programs to identify programs with potential for game changing developments to meet the ARPA-E mission.

In its Stationary Power Systems thrust ARPA-E is focusing on creating a diverse array of technological options that would reduce energy demand and green house gas emissions, create low-cost power generation from traditional and renewable sources, provide greater reliability and security in the delivery of electricity and provide a secure energy foundation for the future.

Some broad goals and benefits of the Stationary Power Systems thrust include electricity generation from solar, wind, natural gas, nuclear, clean coal and other sources to meet base load and peak power at levelized cost of electricity of 5-6 cents/kWh; integrated energy supply systems; low-cost electrical storage; advanced, low-cost and smart components for high-efficiency power transmission, conversion and management at ultrahigh voltages for transmission and medium-to-low voltages for distribution networks; technologies for system-level stability, security, high capacity and reliability; and energy efficiency.

ARPA-E's efforts in the stationary power systems thrust seek to develop clean and efficient power generation through new sources and new production and delivery hardware, increase energy efficiency, and reduce the energy used in manufacturing goods.

Explanation of Funding Changes (Comparable)

(Dollars in Thousands)

	FY 2012 Enacted	FY 2013 Request	FY 2013 Request vs FY 2012 Enacted
Stationary Power Systems. Though exact allocations between thrusts will depend on the applications received, ARPA-E anticipates the funding level for the Stationary Power Systems thrust to be as shown.	104,000	130,000	+26,000
Total, Stationary Power Systems	104,000	130,000	+26,000

Funding and Activity Schedule

The broad field of Stationary Power Systems offers many ripe opportunities for critical research and development. ARPA-E believes there are critical "white spaces" within the field where neither the private sector nor other areas within the DOE are exploring, largely due to the increased-risk early-stage nature of the research and the inherent financial uncertainty.

ARPA-E is planning on investing in the following key areas of Stationary Power Systems:

Conventional power generation facilities – both nuclear and fossil-fuel fired – present extraordinarily harsh conditions under which construction materials must survive and perform. ARPA-E will consider high-risk programs in advanced coolants, computationally-guided discovery of high temperature metal alloys, and advanced manufacturing processes. ARPA-E will focus on the manufacture and integration of high-temperature materials (e.g. those that can withstand 1300 degrees Celsius) for low-cost power generation (e.g. Brayton cycle) through high-efficiency engines. In addition, ARPA-E will coordinate with other DOE offices to investigate radically new molding and manufacturing techniques for jointless radiation-hard, high-temperature materials for advanced nuclear reactors.

The salt concentration gradient where freshwater rivers reach saltwater oceans can be harnessed to create electricity. ARPA-E will consider programs in advanced membranes and osmotic power generation strategies to simultaneously produce electricity and improve desalination efficiency.

As renewable and distributed generation technologies are added to the electric generation mix, energy flow changes from a unidirectional flow – from supply to demand – to a complex bidirectional supply/demand optimization problem. ARPA-E, in coordination with other DOE offices engaged in complimentary activities, will investigate novel operating system/sensor pairings that effectively balance the use of renewable energy sources to maximize both utilization and efficiency and minimize the use of non-renewable energy sources.

Natural gas (methane) currently provides 29% of U.S. energy, and is a clean, lower carbon, energy source. While natural gas combined cycle (NGCC) plants have demonstrated efficiencies of 60% that are superior to coal-fired power plants, ARPA-E will explore programs that convert natural gas into electricity with even higher efficiency than a NGCC plant.

The integration of individual building systems such as lighting, air conditioning, etc. into a single, "smart" building-wide system has the potential to dramatically reduce energy consumption. However, such systems do not yet exist. ARPA-E will consider programs, building off the successes of the ADEPT program as well as in new areas, that reduce the energy consumption through the development of a building operating system, minimizing losses due to unnecessary power usages, the detection and correction of building "faults," a decrease in installation costs with integrated wireless modules, and reduction of electrical losses due to standby power consumption via power management, including the use of wireless technology.

Critical materials are important to many technologies in the energy sector. ARPA-E aims to identify transformational, early-stage applied research and development approaches to address the technical challenges associated with reducing or eliminating the use of critical materials. Specifically, ARPA-E is interested in exploring potentially disruptive wind generators.

Fiscal Year	Activity	Funding (Dollars in Thousands)
FY 2011	In FY 2011, ARPA-E invested in innovations in: Integrating advanced power electronics into solar panels and solar farms to extract and deliver energy more efficiently. Specifically, ARPA-E aims to invest in key advances in magnetics, semiconductor switches, and charge storage, which could reduce power conversion costs by up to 50 percent for utilities and 80 percent for homeowners Novel control software and high-voltage hardware to reliably control the grid network, specifically: 1) cost-optimizing controls able to manage sporadically available sources, such as wind and solar, alongside coal and nuclear, and 2) resilient power flow control hardware – or the energy equivalent of an internet router – to enable automated, real-time control of grid components. Early-stage technology alternatives that reduce or eliminate the dependence on rare earth materials by developing substitutes for wind generators. Revolutionary cost-effective thermal energy storage technologies in two focus areas: 1) high temperature storage systems to deliver solar electricity more efficiently around the clock and allow nuclear and fossil baseload resources the flexibility to meet peak demand and 2) fuel produced from the sun's heat.	100,000
FY 2012	In FY 2012, ARPA-E is planning on investing in innovative technologies to address the following challenges: Hybrid Energy Storage Modules (HESM) that couple and optimize attributes of different energy storage technologies with real-time sensory, analysis, and control techniques to increase efficiency, capacity utilization, reliability, and lifetime across transportation and stationary applications. This FOA was developed jointly with the Department of Defense. A Broad Funding Opportunity Announcement open to all energy ideas and technologies and focused on applicants who already had well-formed research and development plans for potentially high-impact concepts or new technologies.	104,000 (Exact amount unknown until projects are selected)
FY 2013	In FY 2013, ARPA-E is planning to invest in innovative technologies to address the following challenges: Develop clean and efficient power generation technologies that are cost-competitive with today's resources. Develop robust and efficient hardware/software for the future of power transmission, distribution, and end-use. Increase end-use energy efficiency in residential and commercial sectors. Create higher-performing and less energy intensive manufactured goods and services Engage the energy community to develop the next generation of energy technology leadership.	130,000

Program Direction
Funding Profile by Category

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
	(Dollars in Thousands)		
Headquarters			
Salary & Benefits	3,600	6,650	7,875
Travel	800	900	1,500
Support Services	9,200	10,650	13,200
Other Related Expenses	400	1,800	2,425
Total, Headquarters	14,000	20,000	25,000
Full Time Equivalents	22	38	40

Overview

Program Direction provides the Federal staffing resources and associated costs required to provide overall direction and execution of the ARPA-E mission. This budget provides for salaries and benefits of federal staff, federal staff and contractor travel; and support services contracts that provide technical advisory and assistance services. This budget further provides funding for other related expenses, including leased office space and for the DOE Working Capital Fund.

Explanation of Funding AND/OR Program Changes

(Dollars in Thousands)

	FY 2012 Enacted	FY 2013 Request	FY 2013 Request vs FY 2012 Enacted
Salaries and Benefits Increase associated with the growth of federal staff reflects ARPA-E's commitment to the President's initiative to optimize the workforce and reclaim federal responsibilities. Increased federal staff includes additional Program Directors and other technical and professional staff.	6,650	7,875	+1,225
Travel ARPA-E performs significant oversight and diligence on its performers with multiple site visits per year by the Program Director, and this increase reflects more travel to an increased number of award recipient locations to conduct first-hand monitoring and evaluation of progress towards technical deliverables and milestones. This travel is essential to assessing the performer's research efforts and informing any decision to stop targeted programs on the basis of performance. Travel also includes performer community meetings which bring together performers from similar or complimentary technology areas for collaboration.	900	1,500	+600
Support Services ARPA-E expects to initiate support to approximately 100 new projects in FY 2013, a nearly 50 percent increase over the number of projects through FY 2012, but the support services funding level will only increase 33 percent. This reflects ARPA-E's commitment to the President's initiative to optimize the workforce and reclaim federal responsibilities.	10,650	13,200	+2,550

	FY 2012 Enacted	FY 2013 Request	FY 2013 Request vs FY 2012 Enacted
	(Dollars in Thousands)		
Other Related Expenses The increase reflects primarily an increase in the amount of leased space, as well as increased costs commensurate with increased federal staff. DOE is working to achieve economies of scale through an enhanced WCF. The WCF increase covers certain shared, enterprise activities including enhanced cyber security architecture, employee health and testing services, and consolidated training and recruitment initiatives.	1,800	2,425	+625
Total Funding Change, Program Direction	20,000	25,000	+5,000

Support Services by Category

	FY 2012 Enacted	FY 2013 Request	FY 2013 Request vs FY 2012 Enacted
	(Dollars in Thousands)		
Support Services			
Management and Technical Services	6,200	7,650	+1,450
Administrative Services	4,450	5,550	+1,100
Total, Support Services	10,650	13,200	+2,550

Other Related Expenses by Category

	FY 2012 Enacted	FY 2013 Request	FY 2013 Request vs FY 2012 Enacted
	(Dollars in Thousands)		
Other Related Expenses			
Other Services	50	100	+50
DOE/COE	300	400	+100
Working Capital Fund	1,450	1,925	+475
Total, Other Related Expenses	1,800	2,425	+625

Scientific Employment

	FY 2011 Actual	FY 2012 Estimate	FY 2013 Estimate
# of University Grants	30	35	40
Average Size per year ($000)	2,110	2,500	2,850
# Permanent PhD’s (FTEs)	11	15	19
# Postdoctoral Associates (FTEs)	5	7	9
# Graduate Students (FTEs)	0	0	0

GENERAL PROVISIONS

SEC. 301. The unexpended balances of prior appropriations provided for activities in this Act may be available to the same appropriation accounts for such activities established pursuant to this title. Available balances may be merged with funds in the applicable established accounts and thereafter may be accounted for as one fund for the same time period as originally enacted.

SEC. 302. Funds appropriated by this or any other Act, or made available by the transfer of funds in this Act, for intelligence activities are deemed to be specifically authorized by the Congress for purposes of section 504 of the National Security Act of 1947 (50 U.S.C. 414) during fiscal year 2013 until the enactment of the Intelligence Authorization Act for fiscal year 2013.

SEC. 303. Not to exceed 5 percent, or $100,000,000, of any appropriation, whichever is less, made available for Department of Energy activities funded in this Act or subsequent Energy and Water Development and Related Agencies Appropriations Acts may be transferred between such appropriations, but no such appropriation, except as otherwise provided, shall be increased or decreased by more than 5 percent by any such transfers, and any such proposed transfers shall be submitted promptly to the Committees on Appropriations of the House and Senate.

SEC. 304. None of the funds made available in this title shall be used for the construction of facilities classified as high-hazard nuclear facilities under 10 CFR Part 830 unless independent oversight is conducted by the Office of Health, Safety, and Security to ensure the project is in compliance with nuclear safety requirements.

SEC. 305. None of the funds made available in this title may be used to approve critical decision-2 or critical decision-3 under Department of Energy Order 413.3B, or any successive departmental guidance, for construction projects where the total project cost exceeds $100,000,000, until a separate independent cost estimate has been developed for the project for that critical decision.

SEC. 306. (a) The set-asides included in Division C of Public Law 111-8 for projects specified in the explanatory statement accompanying that Act in the following accounts shall not apply to such funds: "Defense Environmental Cleanup", "Electricity Delivery and Energy Reliability", "Energy Efficiency and Renewable Energy", "Fossil Energy Research and Development", "Non-Defense Environmental Cleanup", "Nuclear Energy", "Other Defense Activities", and "Science". (b) The set-asides included in Public Law 111-85 for projects specified in the explanatory statement accompanying that Act in the following accounts shall not apply to such funds: "Electricity Delivery and Energy Reliability", "Energy Efficiency and Renewable Energy", "Fossil Energy Research and Development", "Nuclear Energy", and "Science".

SEC. 307. Of the unobligated balances from prior year appropriations available under the heading "Energy Efficiency and Renewable Energy", $69,667,000 are hereby permanently cancelled: Provided, That no amounts may be cancelled from amounts that were designated by the Congress as an emergency requirement pursuant to the Concurrent Resolution on the Budget or the Balanced Budget and Emergency Deficit Control Act of 1985, as amended

SEC. 501. None of the funds made available by this Act may be used to enter into a contract, memorandum of understanding, or cooperative agreement with, make a grant to, or provide a loan or loan guarantee to any corporation that was convicted (or had an officer or agent of such corporation acting on behalf of the corporation convicted) of a felony criminal violation under any Federal law within the preceding 24 months, where the awarding agency is aware of the conviction, unless the agency has considered suspension or debarment of the corporation, or such officer or agent, and made a determination that this further action is not necessary to protect the interests of the Government.

SEC. 502. None of the funds made available by this Act may be used to enter into a contract, memorandum of understanding, or cooperative agreement with, make a grant to, or provide a loan or loan guarantee to, any corporation that has any unpaid Federal tax liability that has been assessed, for which all judicial and administrative remedies have been exhausted or have lapsed, and that is not being paid in a timely manner pursuant to an agreement with the authority responsible for collecting the tax liability, where the awarding agency is aware of the unpaid tax liability, unless the agency has considered suspension or debarment of the corporation and made a determination that this further action is not necessary to protect the interests of the Government.

SEC. 503. None of the funds made available by this Act may be used in contravention of Executive Order No. 12898 of February 11, 1994 (``Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations'').

Science

Advanced Research Projects Agency-Energy