Fusion Energy Sciences
Funding Profile by Subprogram and Activity

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR*	FY 2014 Request
Science			
DIII-D Research	30,974	—	28,200
Alcator C-Mod Research	10,595	—	0
International Research	8,325	—	8,300
Diagnostics	3,538	—	3,500
Other	7,950	—	8,312
NSTX Research	16,940	—	17,500
Experimental Plasma Research	10,965	—	10,500
High Energy Density Laboratory Plasmas	25,257	—	6,575
Madison Symmetric Torus	6,000	—	5,700
Theory	24,450	—	20,670
SciDAC	8,310	—	6,875
General Plasma Science	16,706	—	15,000
SBIR/STTR	0	—	6,672
Total, Science	170,010	—	137,804
Facility Operations			
DIII-D	38,715	—	36,960
Alcator C-Mod	18,217	—	0
NSTX	33,959	—	36,300
Other, General Purpose Equipment (GPE), and General Plant Projects (GPP)	1,565	—	900
MIE: U.S. Contributions to ITER Project	105,000	—	225,000
Total, Facility Operations	197,456	—	299,160
Enabling R&D			
Plasma Technology	14,652	—	11,660
Advanced Design	2,611	—	1,400
Materials Research	8,228	—	8,300
Total, Enabling R&D	25,491	—	21,360
Total, Fusion Energy Sciences[a]	392,957	403,450	458,324

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

[a] SBIR/STTR funding:
- FY 2012 Appropriation: SBIR $7,085,000 and STTR $954,000 (transferred out of FES in FY 2012 Current column)
- FY 2014 Request: SBIR $5,838,000 and STTR $834,000

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

The Fusion Energy Sciences (FES) program mission is to expand the fundamental understanding of matter at very high temperatures and densities and to build the scientific foundation needed to develop a fusion energy source. This is accomplished 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 essential physics principles.

The pursuit of fusion energy is one of the most challenging programs of scientific research ever undertaken, with manifold potential long-term benefits. Controlled fusion has the potential of delivering base-load power with zero greenhouse gas emissions. Fusion has no possibility of a runaway reaction or meltdown, and any radioactive waste will be low level.

Plasma physics, the science underpinning much of fusion energy research, enables quantitative understanding of a broad class of exotic phenomena observed in the universe. Plasmas—the fourth state of matter—are like gases, but with temperatures high enough that electrons have been knocked free of atomic nuclei through collisions. The Sun is a plasma, and plasma dynamics explain solar flares, galactic jets, and the accretion of material around black holes. Plasma is also 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. Plasma science 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. Practical applications of plasmas are found in lighting, manufacturing, and televisions. The scientific challenge in all cases is that of understanding, predicting, and mastering the control of plasma dynamics.

The leading approach to fusion being studied is the confinement of hot plasma with a magnetic field. This approach is the primary focus of the research conducted in the FES program, and its science has enabled the entirety of the plasma sciences to flourish. Fusion is routinely created and controlled in our research laboratories; experiments have generated millions of watts of fusion power for seconds at a time. Also, we have demonstrated that the ability to control magnetically confined plasmas for fusion—for example, to modify stability and confinement properties and to tailor the equilibrium shape and the pattern of heat exhausted—is grounded in a deep theoretical understanding. However, researchers have not yet tested their ability to control a plasma that is vigorously undergoing fusion to the point of being in the self-heated, or burning, plasma state, in which the amount of fusion power generated is much higher and the length of time it is continuously generated is considerably longer than presently possible.

A second approach to realizing fusion in the laboratory 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—high energy density laboratory plasma physics—that includes and extends beyond inertial fusion. In the past, High Energy Density Laboratory Plasma (HEDLP) physics has been stewarded in part through a program managed and sponsored jointly by the National Nuclear Security Administration (NNSA) and FES. Here again, the science is that of plasma dynamics and control.

The ITER facility being constructed in Cadarache, France, will help us address the scientific challenges presented by the burning plasma state. ITER will be a powerful tool for scientific discovery. It aims to generate fusion power 30 times the levels produced to date and to exceed the external power applied to the plasma by at least a factor of ten. The U.S. is a partner in this international project, and its design and prospects for success hinge critically on U.S. research, project execution, and industry. Executing a plasma sciences program with well-aligned domestic and international components will sustain U.S. international leadership in fusion energy sciences. The U.S. magnetic fusion research program in experiment, theory, and computation is configured to make strong contributions to ITER's science and to bring a high level of scientific return from it. ITER joins the broader FES research portfolio in elevating plasma sciences for both practical benefit and increased understanding of the natural world.

Other opportunities in fusion science include understanding and developing materials that can tolerate the extreme conditions in a fusion environment, including extracting heat and generating fuel in a fusion system. A fusion plasma will present a uniquely hostile environment to the materials of 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 potentially change the materials' strength and other characteristics.

Another opportunity resides in leveraging U.S. computational prowess with experimentally validated simulation as a means for reducing fusion's risks in development and as a tool for discovery. The U.S. has led the world in establishing the strong coupling between detailed measurement and theory that is a hallmark of the fusion and plasma science research enterprise. FES supports much of this work through the Scientific Discovery Through Advanced Computing (SciDAC) program, in concert with the Advanced Scientific Computing Research (ASCR) program. FES will continue to nurture this class of research, including the use of targeted experiments to validate theories that underlie simulation codes.

FES also supports discovery plasma science. Fusion's theory-based computational tools have been used to explain the unexpectedly low brightness of the plasma accretion disk surrounding the super massive black hole at the center of our galaxy. Scaled laboratory experiments enable control and manipulation of plasma states that exhibit characteristics of their extraterrestrial cousins, enabling their study. This class of research is also connected to FES-supported research on the fine-scale manipulation of plasmas at low temperature, which can have profound implications for the efficiency of plasma processes that are used in medical, industrial, and consumer applications.

Basic and Applied R&D Coordination

A discovery-driven program is carried out in concert with the National Science Foundation (NSF), with research extending to a wide range of natural phenomena, including the origin of magnetic fields in the universe and the heating of the solar corona. Also, FES operates a joint program with NNSA in HEDLP physics, which includes discovery-driven research that is central to understanding a range of physical systems, from the cores of the giant planets and the interiors of stars to black hole accretion disks. Both programs involve coordination of solicitations, peer reviews, and workshops. The Fusion Energy Sciences Advisory Committee (FESAC) provides technical and programmatic advice to FES and NNSA for the joint HEDLP program.

Program Accomplishments and Milestones

ITER component fabrication begins. Working with Japan and the ITER Organization, the U.S. ITER Project Office found a solution for manufacturing a qualified conductor with which to construct the superconducting central solenoid magnets. Major design elements for U.S. contributions were completed, including that for the central solenoid magnetic systems. U.S. industrial partners began fabrication of superconducting strand materials for the toroidal field conductor.

New tool developed for suppression of plasma instabilities. An Edge Localized Mode (ELM) is a plasma instability in tokamaks causing potentially violent bursts of heat and particles from the hot, confined plasma. Large ELMs can damage interior components of a tokamak, and avoiding and/or controlling them is critical to preserving plasma stability. One method for making ELMs smaller is the injection of small frozen pellets of fusion fuel at the plasma boundary. New pellet injection experiments on the DIII-D tokamak were able to reduce the energy lost per ELM by 90%. The results will contribute to the scientific basis for our in-kind fabrication of such a system for ITER.

Low-temperature plasma science yields advances in medical sterilization. Researchers have demonstrated that plasmas interacting with water can be controlled to create antibacterial compounds, leaving the water a useful disinfectant for up to seven days. The use of plasma-activated water shows potential for improvement over traditional heat and chemical methods for sterilization of medical equipment and wounds. The Centers for Disease Control and Prevention have estimated that 1.7 million healthcare-associated infections occur each year in the U.S., with direct medical costs approaching $45 billion. Improvements in sterilization technologies will have widespread benefits, especially in low resource and disaster-stricken regions.

New experimental capability expands the breadth of possibilities in high energy density plasma research. The Matter in Extreme Conditions (MEC) endstation at the Linac Coherent Light Source (LCLS) at the SLAC National Accelerator Laboratory was completed ahead of schedule and below budget, and is currently undergoing user-assisted commissioning. MEC currently stands at the forefront of x-ray high-energy-density science, combining the unique high-power optical laser beams of LCLS with a suite of dedicated diagnostics for the investigation of high energy density physics, warm dense matter physics, and high pressure regimes. MEC fabrication was funded through the American Recovery and Reinvestment Act (ARRA).

Progress made in understanding the transition of fusion plasmas into states of high confinement efficiency. A fusion reactor's size and cost are driven substantially by the efficiency of the magnetic bottle used to confine the fusion fuel. Fusion plasmas can spontaneously jump into an enhanced confinement state where that efficiency is roughly doubled, but the physics of this transition has been a lasting puzzle. At DIII-D, a new measurement technique produced the first experimental evidence that the interaction of drift waves with zonal flows is central to the transition to the enhanced confinement state. Also, in coordinated studies across the major U.S. devices, researchers made significant progress toward understanding the resultant plasma state and developing predictive capability from this new understanding.

Plasma-material interaction experiments reveal new physics. Deuterium and tritium are fuels for fusion reactions, and research aims to understand the interaction of tritium with plasma confinement vessel wall materials such as beryllium. Researchers measured for the first time the temperature and heating dependence of the capture and release of deuterium (chemically similar to tritium) from solid beryllium in ITER-like conditions. The results are important for designing how to operate ITER reliably within tritium inventory safety margins.

Innovative method to handle high heat exhaust wins a 2012 R&D 100 Award. A critical problem for a tokamak fusion reactor is distributing the heat exhaust of hundreds of megawatts over a sufficiently large area inside the vacuum chamber. A new concept, which uses a snowflake-shape magnetic configuration in the divertor region, has demonstrated at least a fourfold reduction of the power density in experiments on NSTX, DIII-D, and a tokamak in Switzerland.

Milestones	**Date**
Trim coils designed by PPPL to fine tune the magnetic configuration of the Wendelstein 7-X (W7-X) stellarator in Germany will be completed and delivered to the W7-X site. (International Research)	3rd Qtr, FY 2013
The U.S. ITER Project Office will complete R&D for the ITER roughing pumps and electron cyclotron heating systems, finalize additional procurement arrangements, ship 800 meters of "mock-up" toroidal field conductor to Europe for validation of its coil manufacturing processes, and award the contract for high-voltage transformers for the steady-state electric power network. (U.S. Contributions to ITER Project)	4th Qtr, FY 2013
40% of the fabrication and assembly of the National Spherical Torus Experiment (NSTX) Upgrade will be completed, including the fourth and final inner toroidal field coil quadrant. (NSTX Facility Operations)	4th Qtr, FY 2013
To simulate fusion neutron effects on materials, samples of reduced-activation ferritic (RAF) steel irradiated in the High Flux Isotope Reactor (HFIR) under a U.S.-Japan collaboration will reach 80 displacements per atom. This will provide world-record exposure data for a fusion material and is over half the exposure level expected in a fusion power plant. (Materials Research)	4th Qtr, FY 2013

Milestones	Date
Edge Localized Mode (ELM) instability control techniques that may lead to nearly quiescent conditions on ITER and a reactor will be deployed on the major U.S. facilities and their physics basis assessed by means of a coordinated effort in experiment, theory, and computation. (DIII-D and NSTX Science)	4th Qtr, FY 2013

Program Planning and Management

FES program planning, program evaluation, and priority setting strongly benefit from input and review by outside experts. FES peer review and oversight processes are designed to regularly assess the quality, relevance, and performance of the FES portfolio and are consistent with the President's management agenda.[a]

A hierarchy of sources guides the development of the FES program vision as well as particular programmatic decisions. Studies by the National Research Council (NRC) of the National Academy of Sciences influence the overall FES program vision. 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.

Leading examples of studies that have shaped the FES approach to program planning at the highest level include the 2004 NRC study, *Burning Plasmas: Bringing a Star to Earth*,[b] which underscored the readiness and opportunities for the U.S. to participate in a magnetically confined burning plasma experiment such as ITER, and *Plasma Science: Advancing Knowledge in the National Interest* (2007),[c] which urged SC to exercise strong federal stewardship of general plasma science which includes and goes beyond fusion energy applications. The National Academies recently issued a report *An Assessment of the Prospects for Inertial Fusion Energy* (2013), which evaluated the prospects for and needs of inertial fusion energy (IFE) science and technology.[d]

Fusion Energy Science Advisory Committee (FESAC) activities that have been particularly informative 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 to develop the scientific and technical basis for fusion energy. In 2012, FESAC issued two reports: *International Collaboration in Fusion Energy Sciences Research: Opportunities and Modes during the ITER Era*, and *Materials Science and Technology Research Opportunities Now and in the ITER Era: A Focused Vision on Compelling Fusion Nuclear Science Challenges*. A strategic plan being developed for research in the fusion energy sciences will be informed by all of the sources described above, as well as a recent FESAC report *Priorities of the Magnetic Fusion Science Program* (2013).

Beyond magnetic fusion, FES sponsored a series of workshops during 2008 and 2009 that 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.

Finally, FESAC Committee of Visitors (COV) panels regularly assess the efficacy and quality of the FES processes used to solicit, review, recommend, monitor,

[a] http://www.whitehouse.gov/sites/default/files/omb/memoranda/2012/m-12-14.pdf
[b] Available at http://www.nap.edu/catalog.php?record_id=10816.
[c] Available at http://www.nap.edu/catalog.php?record_id=11960.
[d] Available at http://www.nap.edu/catalog.php?record_id=18289.

and document the application, proposal, and award actions and the quality of the resulting portfolio.

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;
- 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 facilities 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%	25%	75%	0%
Enabling R&D	100%	0%	0%	0%
Total, Fusion Energy Science	35%	15%	50%	0%

Performance Measures

Performance Goal (Measure)	**FES Facility Based Experiments**—Experiments conducted on major fusion facilities (DIII-D, Alcator C-Mod, NSTX) leading toward predictive capability for burning plasmas and configuration optimization		
Fiscal Year	**2012**	**2013**[a]	**2014**
Target	Conduct experiments and analysis on major fusion facilities leading toward improved understanding of core transport and enhanced capability to predict core temperature and density profiles. Assess the level of agreement between predictions from theoretical and computational transport models and the available experimental measurements of core profiles, fluxes and fluctuations. The research is expected to exploit the diagnostic capabilities of the facilities (Alcator C-Mod, DIII-D, NSTX) along with their abilities to run in both unique and overlapping regimes. The work will emphasize simultaneous comparison of model predictions with experimental energy, particle and impurity transport levels and fluctuations in various regimes, including those regimes with significant excitation of electron modes. Along with new experiments, work will include analysis of relevant previously-collected data and collaboration among the research teams. The results achieved will be used to improve confidence in transport models used for extrapolations to planned ITER operation.	Conduct experiments and analysis to explore enhanced confinement regimes without large edge instabilities, but with acceptable edge particle transport and a strong thermal transport barrier. Coordinated experiments, measurements, and analysis will be carried out to assess and understand the operational space for these conditions. Exploiting the complementary parameters and tools of the devices, joint teams will work to strengthen the basis for extrapolation of these regimes to ITER and other future fusion devices.	Conduct experiments and analysis to investigate and quantify plasma response to non-axisymmetric (3D) magnetic fields in tokamaks. Effects of 3D fields can be both beneficial and detrimental and research will aim to validate theoretical models in order to predict plasma performance with varying levels and types of externally imposed 3D fields. Dependence of response to multiple plasma parameters will be explored in order to gain confidence in predictive capability of the models.
Result	Met		

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

Endpoint Target	Magnetic fields are the principal means of confining the hot ionized gas of a plasma long enough to make practical fusion energy. The detailed shape of these magnetic containers leads to many variations in how the plasma pressure is sustained within the magnetic bottle and the degree of control that experimenters can exercise over the plasma stability. These factors, in turn, influence the functional and economic credibility of the eventual realization of a fusion power reactor. The key to their success is a detailed physics understanding of the confinement characteristics of the plasmas in these magnetic configurations. The major fusion facilities can produce plasmas that provide a wide range of magnetic fields, plasma currents, and plasma shapes. By using a variety of plasma control tools, appropriate materials, and having the diagnostics needed to measure critical physics parameters, scientists will be able to develop optimum scenarios for achieving high performance plasmas in ITER and, ultimately, in reactors.

Performance Goal (Measure)	**FES Facility Operations**—Average achieved operation time of FES user facilities as a percentage of total scheduled annual operation time		
Fiscal Year	**2012**	**2013**[a]	**2014**
Target	≥ 90%	≥ 90%	≥ 90%
Result	Met		
Endpoint Target	Many of the research projects that are undertaken at the Office of Science's scientific user facilities take a great deal of time, money, and effort to prepare and regularly have a very short window of opportunity to run. If the facility is not operating as expected the experiment could be ruined or critically setback. In addition, taxpayers have invested millions or even hundreds of millions of dollars in these facilities. The greater the period of reliable operations, the greater the return on the taxpayers' investment.		

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

Explanation of Funding and Program Changes

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 increase for U.S. Contributions to ITER Project from $105,000,000 in FY 2012 to $225,000,000 requested for FY 2014 reflects the acceleration of the project as it enters its full construction phase. The increase will enable the U.S. to accelerate long-lead procurements and is required for the U.S. to meet its obligations to the internationally agreed-upon project schedule.
- *Increases in research and facility operations on the largest domestic confinement experiments*—DIII-D facility run time is increased to 16 weeks, which is 64% of the optimal level. The request also maintains the approved baseline of the NSTX Upgrade project at PPPL.
- *Termination of the research effort at the Massachusetts Institute of Technology's (MIT) Alcator C-Mod tokamak*—Research and facility operations funding provided in FY 2013 will be utilized to complete the safe shutdown of the facility.
- *Consolidation of HEDLP activities*—HEDLP activities are contracted to focus on science at the Matter in Extreme Conditions (MEC) endstation at the Linac Coherent Light Source (LCLS) at SLAC. The joint program with NNSA in HEDLP activities will be discontinued.

	(dollars in thousands)		
	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Science	170,010	137,804	-32,206
C-Mod is shut down, and support for MIT researchers is eliminated. HEDLP activities are contracted to focus on science at the MEC endstation at LCLS. Support for Theory and SciDAC is reduced.			
Facility Operations	197,456	299,160	+101,704
The growth is driven by increases to U.S. Contributions to the ITER Project as the pace of construction accelerates and significant procurement contracts are placed with domestic suppliers for component fabrication. The baseline schedule for the NSTX Upgrade is maintained.			
Enabling R&D	25,491	21,360	-4,131
Reductions will are applied selectively across the activity.			
Total Funding Change, Fusion Energy Sciences	392,957	458,324	+65,367

Science
Funding Profile by Activity

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
DIII-D Research	30,974	—	28,200
Alcator C-Mod Research	10,595	—	0
International Research	8,325	—	8,300
Diagnostics	3,538	—	3,500
Other	7,950	—	8,312
NSTX Research	16,940	—	17,500
Experimental Plasma Research	10,965	—	10,500
High Energy Density Laboratory Plasmas	25,257	—	6,575
Madison Symmetric Torus	6,000	—	5,700
Theory	24,450	—	20,670
SciDAC	8,310	—	6,875
General Plasma Science	16,706	—	15,000
SBIR/STTR[a]	0	—	6,672
Total, Science	170,010	—	137,804

[a] SBIR/STTR Funding
- FY 2012 Appropriation: SBIR $7,084,750 and STTR $954,000 (transferred out of FES in FY 2012 Current column)
- FY 2014 Request: SBIR $5,838,000 and STTR $834,000

Overview

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

- Research at the major experimental facilities aimed at resolving fundamental issues of fusion plasma physics, developing predictive science needed for ITER operations, and providing solutions to high-priority ITER issues.
- Research on small- and medium-scale magnetic confinement experiments to elucidate the physics principles underlying toroidal confinement and to validate theoretical models and simulation codes.
- Research performed at a new generation of international fusion research facilities to exploit their unique capabilities and characteristics, especially in areas that leverage U.S. expertise and that can provide arenas for U.S. influence in program leadership at these experiments.
- Theoretical work on the fundamental description of magnetically confined plasmas and the development of advanced simulation codes on current and emerging high-performance computers.
- Development of unique measurement capabilities and diagnostic instruments to enable experimental validation and provide tools for feedback control of fusion devices.
- Research addressing fundamental scientific questions on high energy density laboratory

plasmas, through experimental, theoretical, and modeling efforts.

- Research that advances basic understanding of the broad, multidisciplinary field of general plasma science, which has far-reaching impacts, from developing new products through low-temperature plasmas to understanding exotic phenomena in the cosmos.

Explanation of Funding Changes

In the FY 2014 request, significant reductions will occur in several program elements.

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
DIII-D Research	30,974	28,200	-2,774
DIII-D research staff will be reduced and the research effort will be concentrated on ITER priority issues.			
Alcator C-Mod Research	10,595	0	-10,595
The C-Mod research effort is ended as the facility is shut down completely with the use of funding provided in FY 2013.			
International Research	8,325	8,300	-25
Scientific collaborations on a new generation of international fusion research facilities, including the EAST (China) and KSTAR (Korea) superconducting tokamaks and the Wendelstein 7-X (Germany) superconducting stellarator, will continue at a constant level of effort.			
Diagnostics	3,538	3,500	-38
Research on advanced diagnostics will continue at approximately the same level of effort.			
Other	7,950	8,312	+362
Funding for the U.S. Burning Plasma Organization (USBPO), Fusion Energy Sciences Advisory Committee (FESAC) activities, and Historically Black Colleges and Universities will be increased.			
NSTX Research	16,940	17,500	+560
NSTX researchers will continue to be involved in collaborations on other domestic and international 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)	10,965	10,500	-465
Research on experiments with emphasis on validation of theoretical models and simulation codes will be reduced.			

	(dollars in thousands)		
	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
High Energy Density Laboratory Plasmas (HEDLP)	25,257	6,575	-18,682
HEDLP activities will be contracted to focus on science at the Matter in Extreme Conditions (MEC) endstation at the Linac Coherent Light Source (LCLS) at SLAC. The joint program with NNSA on HEDLP activities will be discontinued.			
Madison Symmetric Torus (MST)	6,000	5,700	-300
Diagnostic and modeling efforts will be reduced.			
Theory	24,450	20,670	-3,780
The scope of this activity will be narrowed and the level of effort at universities, national laboratories, and private industry—including research staff and graduate students—will be reduced.			
SciDAC	8,310	6,875	-1,435
Funding levels for most projects in the portfolio will decrease. Research in the area of integrated modeling will not be supported, narrowing the scope of the SciDAC activity.			
General Plasma Science	16,706	15,000	-1,706
The overall level of effort will be reduced. Focus will be on targeted investments enhancing progress on fundamental questions of plasma science.			
SBIR/STTR	0	6,672	+6,672
SBIR/STTR funding is statutorily set at 3.2% of non-capital funding in FY 2014. FY 2012 funding of $8,039,000 has been transferred to the SBIR and STTR programs.			
Total Funding Change, Science	170,010	137,804	-32,206

DIII-D Research

Overview

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

The DIII-D research goal is to establish the scientific basis for the optimization of the tokamak approach to magnetic confinement fusion. 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 to obtain conditions scalable to robust operating points and high fusion gain for ITER and future fusion reactors. Near-term targeted efforts address scientific issues important to the ITER design. Longer-term research is focused on advanced scenarios to maximize ITER performance. Another high-priority DIII-D research area is general fusion science, pursuing a basic scientific understanding across all fusion plasma topical areas.

Scientists from many U.S. laboratories and universities participate in the DIII-D research program. The DIII-D program also plays a central role in U.S. international collaborations, hosting many foreign scientists and sending DIII-D scientists to 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 (dollars in thousands)
FY 2012	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, the facility was shut down for maintenance and upgrade activity. Subsequently, high-priority experiments were carried out in the areas of plasma dynamics and control, burning plasma physics, and boundary and pedestal studies. Advanced imaging techniques enabled more detailed studies of the plasma edge region.	30,974
FY 2013	The FY 2013 Request proposed $26,703,000. 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.	—
FY 2014	Research will be conducted in three program areas, with DIII-D staff and collaborator support for diagnostics and data analysis to exploit the additional DIII-D operations in FY 2014: ▪ dynamics and control studies to prepare for burning plasmas in ITER and develop viable steady-state options for fusion energy production ▪ boundary and pedestal research to improve the understanding of Edge Localized Mode control and particle and energy transport in the edge plasma, and ▪ burning plasma physics to advance the predictive capabilities to simulate future devices Studies of 3D field effects will utilize a new enhanced set of magnetic sensors. Disruption mitigation studies will focus on providing a firm physics basis for the ITER disruption mitigation system.	28,200

Alcator C-Mod Research

Overview

C-Mod at the Massachusetts Institute of Technology operated as a national scientific user facility through FY 2012. C-Mod scientists led and participated in USBPO and ITPA topical studies and made significant contributions to the world's fusion program in many areas relevant to burning plasmas. The C-Mod facility is being closed in FY 2013, as described in the Facility Operations section.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	The C-Mod team used a new radio-frequency (RF) antenna developed with ARRA funding. This advanced antenna was designed to match the magnetic field geometry of C-Mod in order to examine plasma antenna interaction effects. The C-Mod team also concentrated 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 was given to performing experiments required to complete the research of the C-Mod graduate students.	10,595
FY 2013	The FY 2013 Request proposed $8,396,000. 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.	—
FY 2014	The Alcator C-Mod facility will be shut down using funding provided in FY 2013, and no additional support for C-Mod research is planned in FY 2014 and beyond.	0

International Research

Overview

In addition to their work on domestic facilities, U.S. researchers participate in experiments at fusion facilities in Europe, Japan, Russia, China, South Korea, and India. Collaborations focus on facilities in the UK (JET), Germany (ASDEX-U), France (Tore Supra), and Japan (Large Helical Device).

U.S. researchers are also beginning to participate in experiments on a new generation of magnetic confinement facilities overseas. Superconducting tokamaks based on U.S. design studies are now operating in China (EAST) and South Korea (KSTAR), and a new superconducting stellarator (Wendelstein 7-X) will begin operation in Germany in late FY 2014. These facilities are making good progress and their directors have expressed strong interest in having a U.S. leadership voice in their programs. Such scientific collaborations help to maintain a vigorous U.S. fusion community that is active at the frontiers of fusion research.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Experiments on JET concentrated on optimizing plasma performance in a facility lined with ITER-like plasma facing components. In ASDEX-U, the focus was on operation with tungsten walls and control of edge instabilities with internal magnet coils. In addition, U.S. researchers applied their expertise in stellarator physics to fabricate a set of trim coils for Wendelstein 7-X for use in joint experiments on stellarator optimization. The first of these coils was delivered to Germany in June 2012.	8,325
FY 2013	The FY 2013 Request proposed $8,946,000. 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.	—
FY 2014	FES will fabricate and deliver the power supplies for the Wendelstein 7-X trim coils. Collaborative efforts will continue and focus on building a close working relationship with the international program teams.	8,300

Diagnostics

Overview

Diagnostics—the scientific instruments used to make detailed measurements of the behavior of plasmas—are key to advancing our abilities to predict and control the behavior of fusion plasmas in a variety of device configurations. Diagnostics are also an excellent vehicle to involve the university and industrial communities in fusion research on major facilities and international collaboration as the FES program advances into the burning plasma era. This program activity involves developing new diagnostic techniques and the theory supporting the application of existing diagnostic methods.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Research was carried out at universities, private industry, and national laboratories on the development of advanced diagnostics. A solicitation was issued to competitively select new and renewal awards at universities and private industry for FY 2013 funding.	3,538
FY 2013	The FY 2013 Request proposed $3,519,000. A solicitation for new research in this program activity for both national laboratories and non-laboratory institutions (universities and private industry) will be issued.	—
FY 2014	Research efforts initiated in FY 2013, as well as continuing efforts at national laboratories, will be maintained at approximately constant level of effort.	3,500

Other

Overview

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

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	U.S. Burning Plasma Organization (USBPO) activities, FESAC, and HBCUs in the fusion and plasma sciences were supported.	7,950
FY 2013	The FY 2013 Request proposed $9,193,000. FES will continue support for all the elements in this category at a reduced level.	—
FY 2014	Funding will support all the elements in this category, with further support for USBPO activities, HBCUs, and FESAC.	8,312

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. A major advantage of this configuration is the ability to confine plasma with pressure that is high compared to the pressure of the magnetic field that confines it. The configuration, with its very strong magnetic curvature, has different confinement and stability properties from those of conventional tokamaks. Research on the ST configuration could lead to the development of smaller, more economical future fusion research facilities.

Research on NSTX is conducted by a collaborative team of physicists and engineers from about 30 U.S. laboratories, universities, and industry groups. NSTX is being upgraded to have a higher magnetic field, higher plasma current, and greater neutral beam heating power and, after completion, will be renamed NSTX Upgrade (NSTX-U).

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	In December 2011, the NSTX team began fabrication of the new center stack and preparations to install the second neutral beam line. The NSTX team analyzed existing data, carried out analyses to support the upgrade project planning for future research operations, and prepared for collaborations on domestic and international facilities.	16,940
FY 2013	The FY 2013 Request proposed $16,836,000. 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.	—
FY 2014	The NSTX research staff will finish up the collaborations on other U.S. and international facilities, complete development of advanced control algorithms for NSTX Upgrade, and work on the design of the next generation of divertor plates, control coils, heating system upgrades, and diagnostics to be implemented during the next five-year research campaign.	17,500

Experimental Plasma Research

Overview

Experimental Plasma Research (EPR) provides 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. Consisting of small-scale experiments primarily at universities, EPR emphasizes plasma physics studies in a wide range of magnetic configurations. Recent investments have supported the operation of a variety of experimental facilities, a center that provides theory and computational support to EPR experiments, and several other investigations.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Emphasis was 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 and simulation codes.	10,965
FY 2013	The FY 2013 Request proposed $10,500,000. 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 portfolios.	—
FY 2014	EPR will test the general validity of plasma physics and technology in a wider expanse of parameter regimes than those provided by the major magnetic confinement facilities.	10,500

High Energy Density Laboratory Plasmas

Overview

High Energy Density Laboratory Plasma (HEDLP) science involves broad, cross-cutting research in areas ranging from laboratory astrophysics to materials under extreme conditions, as well as national security. The Matter in Extreme Conditions (MEC) endstation at the SLAC Linac Coherent Light Source (LCLS) provides access to and diagnosis of high energy density physics, warm dense matter physics, and high pressure regimes.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	A joint solicitation was held by FES and NNSA on discovery-science HEDLP topics identified in the FESAC and ReNeW reports on HEDLP. Awards were recommended for university discovery HEDLP science, laboratory-led discovery HEDLP science, and fundamental IFE science. Additionally, funds were provided for research operations at MEC and the National Drift Compression Experiment-II (NDCX-II) and for ongoing research in heavy ion fusion.	25,257
FY 2013	The FY 2013 Request proposed $16,933,000. 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 re-assessment 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.	—
FY 2014	The HEDLP program will be consolidated to focus on MEC, further developing a world-leading capability for broad HEDLP science unique to the Office of Science. HEDLP community investments through the Joint Program with NNSA will be discontinued.	6,575

Madison Symmetric Torus

Overview

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

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Measurements of the radial profile of fast ions created by neutral beam injection were made with a compact neutral particle analyzer. Also, the MST team designed a low-power antenna for characterizing plasma instabilities.	6,000
FY 2013	The FY 2013 Request proposed $5,750,000. 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.	—
FY 2014	The MST program will focus on RFP experiments and modeling efforts supporting mainline tokamak research. Measurements of short-wavelength density and magnetic field fluctuations, and comparison with gyrokinetic calculations, will be made. Equilibrium reconstructions will be developed for the 3D helical state, and pressure-limiting mechanisms in the RFP will be assessed.	5,700

Theory

Overview

The Theory activity 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 activity is also responsible for providing the scientific grounding for and establishing the 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.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Areas of emphasis included 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 radio-frequency fields with antenna surfaces and plasma, and the further understanding of the potential of 3D magnetic perturbations for attaining improved confinement regimes in tokamak plasmas.	24,450
FY 2013	The FY 2013 Request proposed $20,836,000. 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 an award during the annual theory solicitation.	—
FY 2014	Continuing research activities at universities, national laboratories, and private industry are supported at the FY 2013 level. For the selection of new and renewal awards via competitive merit reviews, priority will be given to theoretical and computational research activities addressing issues of importance to ITER and burning plasmas.	20,670

SciDAC

Overview

The FES Scientific Discovery Through Advanced Computing (SciDAC) activity, a component of the SC-wide SciDAC program, is aimed at advancing scientific discovery in fusion plasma science by exploiting leadership-class computing resources and associated advances in computational science. The FES SciDAC portfolio contributes to the FES goal of advancing the fundamental science of magnetically confined plasmas to develop the predictive capability 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 (dollars in thousands)
FY 2012	The five FES SciDAC Centers competitively selected in FY 2011 continued 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. Two new multi-institutional interdisciplinary Centers in the areas of edge physics and computational materials science, co-funded by FES and ASCR, joined 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*.	8,310
FY 2013	The FY 2013 Request proposed $6,556,000. 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.	—
FY 2014	Research activities are maintained at approximately the FY 2013 level of effort. The two partnerships selected in FY 2012 will undergo a mid-term progress review.	6,875

General Plasma Science

Overview

The General Plasma Science (GPS) program focuses on increasing the understanding of basic and low-temperature plasma science through research addressing outstanding questions related to fundamental plasma properties and processes, as well as multidisciplinary activities. Major activities of the program are the NSF/DOE Partnership in Basic Plasma Science and Engineering, which supports university single-investigator-scale research; Plasma Science Centers, which are focused multi-institutional teams (specifically the Low Temperature Plasma Science Center, the Center for Magnetic Turbulence and Flow Self-Organization, and the Max Planck-Princeton Center for Plasma Physics); intermediate-scale facilities; and basic and applied plasma science research at DOE national laboratories.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	The major elements of the GPS program continued with the annual solicitation of the NSF/DOE Partnership in Basic Plasma Science and Engineering and with FES participation in the Center for Magnetic Self Organization (an NSF Frontier Science Center at the University of Wisconsin) and in the Basic Plasma Science Facility (at UCLA). The Plasma Science Centers addressed predictive control of kinetic processes in low temperature plasmas and self-organization processes of momentum and turbulence in plasmas. An international center for plasma physics using both DOE and NSF funds was established involving PPPL, Princeton University, and the Max Planck Society of Germany.	16,706
FY 2013	The FY 2013 Request proposed $13,151,000. 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.	—
FY 2014	Core activities will be enhanced, including interagency partnerships, Plasma Science Centers, and user activities at the Basic Plasma Science Facility.	15,000

Facility Operations
Funding Profile by Activity

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
DIII-D	38,715	—	36,960
Alcator C-Mod	18,217	—	0
NSTX	33,959	—	36,300
Other, General Purpose Equipment (GPE), and General Plant Projects (GPP)	1,565	—	900
MIE: U.S. Contributions to ITER Project	105,000	—	225,000
Total, Facility Operations	197,456	—	299,160

Overview

The Facility Operations subprogram mission is to provide support 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 to advance progress toward a fusion energy source.

The current major experimental user facilities in the FES program—the DIII-D tokamak at General Atomics in San Diego, California, and NSTX at the Princeton Plasma Physics Laboratory (PPPL) in Princeton, New Jersey—provide critical tools for the U.S. and international research community to explore and resolve fundamental issues of fusion plasmas. Both DIII-D and NSTX are operated as national scientific user facilities and involve users from many laboratories, industries, and universities. The support for these facilities is balanced to ensure safe operation; provide modern experimental tools such as heating, fueling, and exhaust systems; and provide the operating time to meet the needs of users 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-heated (burning) plasmas and will thus open a new era in fusion energy science.

Explanation of Funding Changes

As ITER construction activities 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. NSTX will not operate in FY 2014, while efforts focus on completion of the upgrade by FY 2015. The Alcator C-Mod facility shutdown will be completed with funding provided in FY 2013. The DIII-D tokamak will be the only major fusion experiment operating in the U.S. during FY 2014, and operating time will be increased to accommodate demand.

	(dollars in thousands)		
	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
DIII-D	38,715	36,960	-1,755
Run time will be increased from 15 weeks to 16 weeks. Only high- priority tokamak system refurbishments to improve the reliability of operations and targeted facility upgrades, such as further enhancements of the microwave heating system, will be supported. Other upgrades will be deferred in order to enhance run weeks.			
Alcator C-Mod	18,217	0	-18,217
The safe shut-down of the Alcator C-Mod facility will be completed with funding provided in FY 2013.			
NSTX	33,959	36,300	+2,341
Overall funding for NSTX Facility Operations and the NSTX-U major item of equipment (MIE) project is increased. Priority is given to the NSTX-U project so that it can be completed in FY 2015. The non-MIE Facility Operations funding will support critical facility and diagnostic upgrades important to the future NSTX-U research program, including power supplies, control systems, and long-pulse diagnostics.			
Other, General Purpose Equipment (GPE), and General Plant Projects (GPP)	1,565	900	-665
Funding, which supports non-research infrastructure PPPL, will be reduced.			
U.S. Contributions to ITER Project (MIE)	105,000	225,000	+120,000
The funding increase will enable the U.S. to place significant procurement contracts with domestic suppliers for fabrication of components and increase deliveries of in-kind components to the ITER Organization in fulfillment of internationally agreed-upon obligations.			
Total Funding Change, Facility Operations	197,456	299,160	+101,704

DIII-D

Overview

The DIII-D user facility 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 for studying stability, confinement, and other properties of fusion-grade plasmas under a wide variety of conditions.

DIII-D has considerable experimental flexibility and extensive world-class diagnostic instrumentation to measure the properties of high-temperature tokamak plasmas. Capabilities of this 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.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	After a few weeks of operation in October 2011, the facility completed a 4-month maintenance and upgrade period. During this time, work continued on the Recovery Act upgrade to the microwave heating system to add a 7^{th} high-power microwave tube (gyrotron). An advanced infrared/visible viewing system (periscope) was also installed. Research operations were conducted in the second half of FY 2012 to complete 15 weeks of experiments.	38,715
FY 2013	The FY 2013 Request proposed $33,260,000. 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.	—
FY 2014	Research operations will be increased to 16 weeks. Work on some targeted, high-priority upgrades and diagnostic enhancements, such as continued improvements to the microwave heating system, will be supported. A new 3D magnetic coil sensor system will be used to support research.	36,960

Alcator C-Mod

Overview

The compact size and high field of the Alcator C-Mod tokamak made it especially useful for dimensionless scaling studies relevant to ITER and future fusion reactors. It also contributed to research on plasma-wall interactions and radio-frequency wave heating.

The Alcator C-Mod facility will be put in a safe shutdown configuration by the end of FY 2013. Some of the C-Mod research staff may transition to other activities.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Research operations continued at the beginning of FY 2012 with the use of the new advanced ion cyclotron RF antenna. New fast ferrite tuners (funded by the Recovery Act) were ordered for installation on three RF transmitters to allow for more efficient power coupling to the plasma. A total of 18 weeks of research operations was planned, and 19 weeks were achieved.	18,217
FY 2013	The FY 2013 Request proposed $7,848,000. 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.	—
FY 2014	The facility closure will be completed. No research operations will be planned in FY 2014 and beyond.	0

NSTX

Overview

The NSTX user facility 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 plasma with pressure that is high compared to the magnetic field energy density.

The NSTX Upgrade MIE project is currently underway. The new center stack will double the magnetic field and plasma current, while increasing the plasma pulse length to 5 seconds, making NSTX the world's highest-performing ST. The addition of a second neutral beam system will double the heating power, which 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 support a strong research program to develop the improved understanding of the ST magnetic confinement configuration required to establish the physics basis for next-step ST facilities, broaden scientific understanding of plasma confinement, and maintain U.S. world leadership in ST research. The capability for controllable fully-non-inductive current drive will also contribute to an assessment of the ST as a potentially cost-effective path to fusion energy. The total project cost (TPC) baseline of $94,300,000 was approved at Critical Decision-2 (CD-2) in December 2010, and CD-3 approval to start fabrication was achieved in December 2011. Project completion is anticipated in FY 2015.

In parallel with the upgrade, preparations for the resumption of facility operations are underway, including minor upgrades of diagnostics, control systems, data acquisition and data analysis systems.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	$13,514,000 supported maintenance and repairs on all of the systems that are not involved in the upgrade project. NSTX Upgrade activities included initiating machine disassembly, continuing refurbishment of the neutral beam, and continuing component fabrication and assembly, including the machining of the toroidal field inner coils.	33,959
FY 2013	The FY 2013 Request proposed $6,593,000. 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.	—
FY 2014	As upgrade work continues, NSTX will continue its shut down. Installation of the new center stack assembly and the second neutral beamline will be completed. Operations funding of $12,600,000 will support preparation of the systems not involved in the upgrade for resumption of operation in FY 2015.	36,300

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
NSTX Operations	13,514	—	12,600
NSTX Upgrade (MIE)	20,445	—	23,700
Total	33,959	—	36,300

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

Overview

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

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	An uninterruptable power supply, new window assemblies, and drainage modifications on various buildings were installed. Environmental monitoring needs were supported. Prior Recovery Act funding to improve PPPL's infrastructure reduced the need for GPP funding in the near term.	1,565
FY 2013	The FY 2013 Request proposed $975,000. Funding will upgrade the chilled water system and various fire alarm systems and will support environmental monitoring needs.	—
FY 2014	Modification to the Emergency Services Building to improve its waterproofing, Phase 2 of the underground chilled water utility upgrade, and upgrade of the Large Torus Building/Carpentry shop roofing system will be completed. Environmental monitoring needs will be supported.	900

U.S. Contributions to ITER Project (MIE)

Overview

The ITER Project is building a research facility capable of generating the world's first sustained (300 seconds, self-heated) burning plasma. The research at 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 (the host). The U.S. remains committed to the scientific mission of ITER and will work with ITER partners to accomplish this goal, while maintaining a balanced domestic research portfolio.

The U.S. Contributions to ITER Project (U.S. ITER Project) MIE activity is 9.09% of the ITER Project construction costs. The US contributions, consisting of in-kind hardware components, personnel, and cash to the ITER Organization (IO) for the ITER construction phase, are established by the terms of the ITER Joint Implementation Agreement. The US contributions are managed by the U.S. ITER Project Office (USIPO), located at Oak Ridge National Laboratory (ORNL), in partnership with Princeton Plasma Physics Laboratory and Savannah River National Laboratory. The U.S. ITER Project differs from most other DOE and Office of Science (SC) projects in its in-kind hardware contribution obligations and in the risks associated with performing work that depends in large part on the execution of project responsibilities by our international partners. In December 2012, the Deputy Secretary issued a memorandum clarifying the U.S. ITER Project's designation within DOE's portfolio of projects. Due to its many unique features, the U.S. ITER Project was found to fall outside the definition of a Capital Asset project. This clarification enables better definition of project requirements and roles and responsibilities within the Department for project planning, execution, and oversight.

This clarification has not changed SC's overall management approach for the U.S. ITER Project. As with all SC projects, the principles encoded in DOE Order 413.3b will be applied including critical decision milestones and their supporting prerequisite activities. Requirements for project documentation, monitoring and reporting, change control, and regular independent peer reviews will be applied with the same degree of rigor.

The U.S. ITER Project CD-1 cost range established in 2008 is $1,450,000,000 - $2,200,000,000. Since that time, factors that delayed CD-2 approval (e.g., schedule delays, design and scope changes, and risk mitigations) have also placed upward pressure on the cost range. In the spring of 2012, in efforts to address budgetary constraints, DOE and its oversight organizations agreed to support an annual funding level of no more than $225,000,000 per year beginning in FY 2014. DOE believes these annual funding levels will enable the U.S. to fulfill its obligations. The achievement of First Plasma is the primary major milestone on the path to total project completion as it signifies completion of machine assembly, integration, and commissioning in support of initial operations. At this annual funding level, the pre-CD-2 estimate for the total cost to meet the U.S. obligations for First Plasma, a subset of our total obligations, is $2,400,000,000. This total cost is not a bottom-up estimate but is the judgment by DOE and its oversight organizations of appropriate cost for reaching first plasma. Before establishing a formal CD-2 project baseline for First Plasma scope or total U.S. commitments, and in consideration of this pre-CD-2 cost determination, the U.S. will initiate further discussions with the leadership of the ITER Organization and the ITER Members regarding how the project can best be completed within U.S. spending constraints.

Until such time as CD-2 can be approved, the U.S. contributions will be managed with a performance plan that focuses on a two-year time horizon and that is also supportive of the longer-term project requirements. This two-year plan is developed, executed, and monitored with the use of the project management principles in DOE Order 413.3b with project management systems (Earned Value, Risk Management, Project Reporting) tailored specifically to this project's circumstances.

Current U.S. ITER Project efforts are focused on procurement and fabrication of U.S. in-kind commitments to ITER. The substantial increase in funding for the U.S. ITER Project in FY 2014 is driven by the ITER construction schedule, which requires support for significant ongoing contracts with U.S. suppliers and the production of in-kind hardware components. Over 80% of the U.S. contributions to the ITER MIE Project funding will be spent on in-kind hardware sourced from U.S. industries, national laboratories, and universities.

The FY 2013–2014 scope of the U.S. ITER Project spans all twelve technical subsystems that the U.S. is responsible for providing. Performance milestones have been identified for the FY 2013–2014 work scope against which performance will be measured. Project cost estimates that support the work scope proposed in the plan are based on a resource-loaded schedule. The plan has been reviewed by the Office of Project Assessment and an independent panel. The majority (by cost) of the work scope proposed in this Plan is in Final Design or beyond with an estimated eight final design reviews planned for either components (partial sub-system) or entire technical subsystem reviews in the next two years. The plan assumes $150,000,000 to be available in FY 2013, per the Administration request to Congress, and $225,000,000 in FY 2014, per this budget proposal. The plan, including the scope of deliverables, will be revisited when the final FY 2013 funding level is determined.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Ongoing design activities and the placement of contracts for the U.S. contributions to ITER construction were supported. These contracts included 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.	105,000
FY 2013	The FY 2013 Request proposed $150,000,000. The proposed funding will continue fabrication activities ($89M), mostly performed by U.S. companies, for ongoing U.S. systems. At the request level, the USIPO will continue work toward completion of designs for several key U.S. systems. As part of the FY 13 request, the U.S. will provide a cash contribution to the project in accordance with the ITER Organization (IO) budget request ($31M).	—
FY 2014	According to the plan reviewed by the Office of Project Assessment and an independent panel, the U.S. ITER Project Office proposes to deliver to the ITER Organization four shipments of toroidal field conductor, drain tanks for tokamak cooling water, and hardware for the steady-state electrical network, as well as start fabrication of the first central solenoid module, complete various design reviews for the vacuum auxiliary system, and award subcontracts for diagnostic design work.	225,000

Design and Construction Schedule

	CD-0	CD-1	Design Complete	CD-2	CD-3	CD-4
FY 2006	7/5/2005	TBD	TBD	TBD	TBD	TBD
FY 2007	7/5/2005	TBD	TBD	4Q FY 2007	TBD	TBD
FY 2008	7/5/2005	1/25/2008	TBD	4Q FY 2008	TBD	TBD
FY 2009	7/5/2005	1/25/2008	TBD	4Q FY 2010	TBD	TBD
FY 2010	7/5/2005	1/25/2008	TBD	4Q FY 2011	TBD	TBD

	CD-0	CD-1	Design Complete	CD-2	CD-3	CD-4
FY 2011	7/5/2005	1/25/2008	TBD	4Q FY 2011	TBD	TBD
FY 2012	7/5/2005	1/25/2008	TBD	3Q FY 2012	TBD	TBD
FY 2013	7/5/2005	1/25/2008	TBD	TBD[a]	TBD	TBD
FY 2014	7/5/2005	1/25/2008	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 Project Completion

Funding Profile History (DOE Only)

(dollars in thousands)

Request Year		Prior Years	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	Outyears	Total
FY 2006	TEC	358,000	191,000	189,000	151,000	120,000	29,000	0	0	1,038,000
	OPC	38,300	16,500	10,300	9,300	6,200	3,400	0	0	84,000
	TPC	396,300	207,500	199,300	160,300	126,200	32,400	0	0	1,122,000
FY 2007	TEC	202,366	208,500	208,500	180,785	130,000	116,900	30,000	0	1,077,051
	OPC	36,949	6,000	1,500	500	0	0	0	0	44,949
	TPC	239,315	214,500	210,000	181,285	130,000	116,900	30,000	0	1,122,000
FY 2008	TEC	202,366	208,500	208,500	181,964	130,000	116,900	30,000	0	1,078,230
	OPC	36,949	6,000	821	0	0	0	0	0	43,770
	TPC	239,315	214,500	209,321	181,964	130,000	116,900	30,000	0	1,122,000
FY 2009	TEC	54,866	208,500	TBD	TBD	TBD	TBD	TBD	TBD	TBD
	OPC	32,075	6,000	TBD	TBD	TBD	TBD	TBD	TBD	TBD
	TPC	89,941	214,500	TBD	TBD	TBD	TBD	TBD	TBD	TBD
FY 2010	TEC	80,366	109,000	105,000	TBD	TBD	TBD	TBD	TBD	TBD
	OPC	25,019	15,000	30,000	TBD	TBD	TBD	TBD	TBD	TBD
	TPC	105,385	124,000	135,000	TBD	TBD	TBD	TBD	TBD	TBD

[a] The CD-2 date will be determined upon acceptable resolution of outsanding issues related to US in-kind contributions including: final definition of interfaces for US contributions with buildings and non-U.S. systems under construction as well as finalization of French nuclear regulatory requirements.

(dollars in thousands)

Request Year		Prior Years	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	Outyears	Total
FY 2011	TEC	80,366	109,000	115,000	75,000	TBD	TBD	TBD	TBD	TBD
	OPC	25,019	15,000	20,000	5,000	TBD	TBD	TBD	TBD	TBD
	TPC	105,385	124,000	135,000	80,000	TBD	TBD	TBD	TBD	TBD
FY 2012	TEC	80,366	109,000	115,000	TBD	90,000	TBD	TBD	TBD	TBD
	OPC	25,019	15,000	20,000	TBD	15,000	TBD	TBD	TBD	TBD
	TPC	105,385	124,000	135,000	TBD	105,000	TBD	TBD	TBD	TBD
FY 2013	TEC	80,366	109,000	115,000	67,000	104,930	140,965	TBD	TBD	TBD
	OPC	25,019	15,000	20,000	13,000	70	9,035	TBD	TBD	TBD
	TPC	105,385	124,000	135,000	80,000	105,000	150,000	TBD	TBD	TBD
FY 2014	TEC	80,366	109,000	115,000	67,000	104,930	105,572	225,000	TBD	TBD
	OPC	25,019	15,000	20,000	13,000	70	70	0	TBD	TBD
	TPC	105,385	124,000	135,000	80,000	105,000	105,642[a]	225,000	TBD	TBD

[a] The FY 2013 amount shown reflects the P.L. 112-175 continuing resolution level annualized to a full year and based on the FY 2012 funding level for ITER. The TEC total and outyear appropriation assumptions have not been adjusted to reflect the final FY 2013 level; the FY 2013 Request level is assumed instead..

Enabling R&D
Funding Profile by Activity

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Plasma Technology	14,652	—	11,660
Advanced Design	2,611	—	1,400
Materials Research	8,228	—	8,300
Total, Enabling R&D	25,491	—	21,360

Overview

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

Explanation of Funding Changes

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

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Plasma Technology	14,652	11,660	-2,992
Maintain at a reduced level all technology elements, including heating, fueling, and magnets.			
Advanced Design	2,611	1,400	-1,211
Reduce effort on scoping studies to characterize significant research gaps in the materials and fusion nuclear sciences program.			
Materials Research	8,228	8,300	+72
Increase modestly the effort in both experiments and modeling activities.			
Total Funding Change, Enabling R&D	25,491	21,360	-4,131

Plasma Technology

Overview

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

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Efforts in all areas identified above continued, including research on issues of tritium-materials interaction in the ITER mixed-material environment of tungsten, carbon, and beryllium. A series of material science experiments was continued under a U.S.-Japan collaborative program on plasma-facing and blanket materials for use in future facilities.	14,652
FY 2013	The FY 2013 Request proposed $11,666,000. 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.	—
FY 2014	Efforts in all areas will be maintained to address the challenges and gaps in the program. A new U.S. Japan collaborative program will engage in a materials characterization initiative to evaluate improved tungsten alloys as a viable plasma-facing material capable of withstanding the harsh fusion environment.	11,660

Advanced Design

Overview

Advanced Design funding provides support for conceptual studies of potential fusion systems. These studies help to identify the various scientific challenges to fusion energy and determine how to address them. In addition, this activity supports program planning activities and the Virtual Laboratory for Technology (VLT), an organization that coordinates fusion technology research throughout the country.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Efforts continued on the study of plasma-material interaction and control issues for fusion power plants.	2,611
FY 2013	The FY 2013 Request proposed $1,611,000. 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.	—
FY 2014	Efforts will focus on identifying gaps in materials and nuclear science.	1,400

Materials Research

Overview

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

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Efforts continued on R&D activities dedicated to materials and joining technologies. The focus was 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 (ODS) steels, and silicon carbide (SiC) composites were investigated.	8,228
FY 2013	The FY 2013 Request proposed $9,371,000. 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.	—
FY 2014	Efforts will continue in all activities identified above. The focus will be on joining of ODS steels and SiC composites, fabrication of tungsten and corrosion resistant steels, liquid divertors and first wall technologies, and modeling/simulation of solid state and liquid materials.	8,300

Supporting Information

Capital Operating Expenses

Capital Operating Expenses Summary

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Operating expenses	263,290	—	208,499
Capital equipment over $500,000, including major items of equipment (MIEs)	128,612	—	249,425
General plant projects (GPP) (under $10 million)	1,055	—	400
Total, Fusion Energy Sciences	392,957	403,450	458,324

Capital Equipment over $500,000 (including MIEs)

(dollars in thousands)

	Total	Prior Years	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Major items of equipment (TEC over $2 million)					
National Spherical Torus Experiment Upgrade					
TEC	83,665	13,250	20,445	—	23,700
OPC	10,635	10,635	0	—	0
TPC	94,300	23,885	20,445	—[a]	23,700
U.S. Contributions to ITER					
TEC	TBD	371,366	104,930	—	225,000
OPC	TBD	73,019	70	—	0
TPC	TBD	444,385	105,000	—	225,000
Total MIEs					
TEC			125,375	—	248,700
OPC			70	—	0
TPC			125,445	—	248,700

[a] The TEC, OPC, and TPC totals have not been adjusted to reflect the final FY 2013 funding level; the FY 2013 Request level of $20,570,000 is assumed instead.

	(dollars in thousands)				
	Total	Prior Years	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Other capital equipment projects under $2 million TEC			3,167	—	725
Total, Capital equipment (excludes MIE OPC)			128,612	—	249,425

Facility Operations MIEs:

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

U.S. Contributions to ITER. This MIE project funds the U.S. 9.09% share of in-kind hardware, personnel, 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 under construction.

Other Supporting Information

Funding Summary

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Research	195,501	—	159,164
Scientific user facility operations	70,446	—	49,560
Major items of equipment	125,445	—	248,700
Other (GPP, GPE, and infrastructure)	1,565	—	900
Total, Fusion Energy Sciences	392,957	403,450	458,324

Scientific User Facility Operations and Research

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
DIII-D			
Operations	38,715	—	36,960
Facility Research	30,974	—	28,200
Total, DIII-D	69,689	—	65,160
Alcator C-Mod			
Operations	18,217	—	0
Facility Research	10,595	—	0
Total, Alcator C-Mod	28,812	—	0
NSTX			
Operations	13,514	—	12,600
Facility Research	16,940	—	17,500
Total, NSTX	30,454	—	30,100
Scientific user facilities operations and research			
Operations	70,446	—	49,560
Facility Research	58,509	—	45,700
Total, Scientific user facilities operations and research	128,955	—	95,260

Facilities Users and Hours

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
DIII-D National Fusion Facility			
Achieved operating hours	608	—	N/A
Planned operating hours	520	—	640
Optimal hours	1,000	—	1,000
Percent of optimal hours	61%	—	64%
Unscheduled downtime hours	32	—	N/A
Number of users	230	—	250
Alcator C-Mod			
Achieved operating hours	608	—	N/A
Planned operating hours	544	—	0
Optimal hours	800	—	0
Percent of optimal hours	76%	—	0%
Unscheduled downtime hours	24	—	N/A
Number of users	194	—	0
National Spherical Torus Experiment			
Achieved operating hours	0	—	N/A
Planned operating hours	0	—	0
Optimal hours	0	—	0
Percent of optimal hours	N/A	—	N/A
Unscheduled downtime hours	0	—	N/A
Number of users	145	—	165
Total, Facilities users and hours			
Achieved operating hours	1,216	—	N/A
Planned operating hours	1,064	—	640
Optimal hours	1,800	—	1,000
Percent of optimal hours (funding weighted)	68%	—	64%
Unscheduled downtime hours	56	—	N/A
Number of Users	569	—	415

Scientific Employment

	FY 2012 Actual	FY 2013 Estimate	FY 2014 Estimate
Number of university grants	325	—	265
Number of laboratory projects	158	—	150
Number of permanent Ph.D.'s (FTEs)	760	—	667
Number of postdoctoral associates (FTEs)	115	—	80
Number of graduate students (FTEs)	325	—	243
Number of Ph.D.'s awarded	42	—	41