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.

<u>Basic and Applied R&D Coordination</u>

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.

<u>Program Accomplishment and Milestones</u>

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.			
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 7^{th} 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

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
	(Dollars in Thousands)		
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