Fusion Energy Sciences

Overview

The Fusion Energy Sciences (FES) program mission is to expand the fundamental understanding of matter at very high temperatures and densities and to build the scientific foundation needed to develop a fusion energy source. This is accomplished through the study of plasma, the fourth state of matter, and how it interacts with its surroundings. The interdisciplinary nature of modern fusion research is emphasized in the 2015 Quadrennial Technology Review.

The next frontier for all of the major fusion research programs around the world is the study of the burning plasma state, in which the fusion process itself provides the dominant heat source for sustaining the plasma temperature (i.e., self-heating). Production of strongly self-heated fusion plasma will allow the discovery and study of new scientific phenomena relevant to fusion energy. These include the effects of highly energetic fusion-produced alpha particles on plasma stability and confinement; the strongly nonlinear coupling that will occur among fusion alpha particles, pressure-driven self-generated current, turbulent transport, and boundary-plasma behavior; the properties of materials in the presence of high heat and particle fluxes and neutron irradiation; and the self-organized nature of plasma profiles over long time scales.

To achieve these research goals, FES invests in flexible U.S. experimental facilities of various scales, international partnerships leveraging U.S. expertise, large-scale numerical simulations based on experimentally validated theoretical models, development of advanced fusion-relevant materials, and invention of new measurement techniques.

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

To support the program mission and its major focus, the U.S. fusion program has four elements:

- Burning Plasma Science: Foundations;
- Burning Plasma Science: Long Pulse;
- Burning Plasma Science: High Power; and
- Discovery Plasma Science.

Highlights of the FY 2017 Budget Request

Notable changes in the FY 2017 budget include:

- *No funding is provided for Alcator C-Mod operation and research*—after the final year of operation of Alcator C-Mod in FY 2016, the research staff at the MIT Plasma Science and Fusion Center will shift focus to begin full-time collaborative research activities in the DIII-D and NSTX-U national research programs; in addition, some will engage in collaborations with international laboratories.
- *Increased support for DIII-D and National Spherical Torus Experiment-Upgrade (NSTX-U) research*—Funding for the DIII-D and NSTX-U research programs is increased to address the high priority fusion science issues identified by the community research needs workshops held in FY 2015 and to support enhanced collaborations with MIT researchers.
- *Continued support to the U.S. Contributions to ITER Project*—Funding will support continued progress on in-kind hardware contributions, including central solenoid superconducting magnet modules and structures, toroidal field magnet conductor, steady-state electrical network components, and tokamak cooling water system. Funding is also provided toward the FY 2017 monetary contribution to the ITER Organization, which supports ITER Project common expenses.
- In the FY 2017 Budget Request, most funding for the Working Capital Fund (WCF) is transferred to Program Direction to establish a consolidated source of funding for goods and services provided by the WCF. CyberOne is still funded through program dollars in the SC Safeguards and Security program. In FY 2016 and prior years, WCF costs were shared by SC research programs and Program Direction.

Fusion Energy Sciences
Funding ($K)

	FY 2015 Enacted	FY 2015 Current[a]	FY 2016 Enacted	FY 2017 Request[b]	FY 2017 vs. FY 2016
Fusion Energy Sciences					
Burning Plasma Science: Foundations					
Advanced Tokamak	105,348	107,675	101,255	84,238	-17,017
Spherical Tokamak	72,919	71,169	74,000	73,199	-801
Theory & Simulation	34,670	35,006	33,500	33,170	-330
GPE/GPP/Infrastructure	3,125	3,600	6,000	5,000	-1,000
Total, Burning Plasma Science: Foundations	**216,062**	**217,450**	**214,755**	**195,607**	**-19,148**
Burning Plasma Science: Long Pulse					
Long Pulse: Tokamak	7,695	7,895	8,500	6,045	-2,455
Long Pulse: Stellarators	6,419	8,010	7,269	5,084	-2,185
Materials & Fusion Nuclear Science	24,842	23,033	25,252	20,226	-5,026
Total, Burning Plasma Science: Long Pulse	**38,956**	**38,938**	**41,021**	**31,355**	**-9,666**
Discovery Plasma Science					
Plasma Science Frontiers	46,024	44,643	46,784	31,916	-14,868
Measurement Innovation	3,575	3,575	6,700	4,000	-2,700
SBIR/STTR & Other	12,883	2,760	13,740	10,300	-3,440
Total, Discovery Plasma Science	**62,482**	**50,978**	**67,224**	**46,216**	**-21,008**
Subtotal, Fusion Energy Sciences	**317,500**	**307,366**	**323,000**	**273,178**	**-49,822**
Construction					
14-SC-60 International Thermonuclear Experimental Reactor (ITER)	150,000	150,000	115,000	125,000	+10,000
Total, Fusion Energy Sciences	**467,500**	**457,366**	**438,000**	**398,178**	**-39,822**

SBIR/STTR:

- FY 2015 Transferred: SBIR $8,906,000 and STTR $1,228,000
- FY 2016 Projected: SBIR: $9,333,000; STTR: $1,400,000
- FY 2017 Request: SBIR $8,436,000 and STTR $1,186,000

[a] Reflects the transfer of Small Business Innovation/Technology Transfer Research (SBIR/STTR) funds within the Office of Science.

[b] A transfer of $861,000 to Science Program Direction to consolidate all Working Capital Funds in one program.

Fusion Energy Sciences
Explanation of Major Changes ($K)

	FY 2017 vs FY 2016
Burning Plasma Science: Foundations: Overall funding for advanced tokamak research is decreased, as operation of Alcator C-Mod ceases. Funding for DIII-D and NSTX-U research is increased to support the enhanced collaboration by MIT research staff in those programs. Funding for Theory & Simulation is increased to accelerate progress toward whole-device modeling. Decreased funding for DIII-D and NSTX-U operations results in deferment of some facility enhancements and a slight reduction to operating weeks.	**-19,148**
Burning Plasma Science: Long Pulse: Overall funding is decreased for U.S. research collaborative activities on overseas long-pulse tokamaks and stellarators and on research and experimental capabilities that address the plasma-materials interface scientific challenge.	**-9,666**
Discovery Plasma Science: Overall funding is decreased, as the High Energy Density Laboratory Plasma science activity contracts to focus on supporting research utilizing the Matter in Extreme Conditions instrument of the Linac Coherent Light Source at the SLAC National Accelerator Laboratory. Decreases in Measurement Innovation and General Plasma Science activities result from the completion of targeted research enhancements fully funded in FY 2016.	**-21,008**
Construction: Funding is provided toward the FY 2017 monetary contribution (total $44M) to the ITER Organization.	**+10,000**
Total Funding Change, Fusion Energy Sciences	**-39,822**