DEPARTMENT OF ENERGY
FY 1999 CONGRESSIONAL BUDGET REQUEST
ENERGY SUPPLY
(Tabular dollars in thousands, Narrative in whole dollars)

FUSION ENERGY SCIENCES

PROGRAM MISSION

The Fusion Energy Sciences program is a broad-based, fundamental research effort, producing valuable scientific knowledge and practical benefits in the near term and, in cooperation with our international partners, making substantial progress toward an economically and environmentally attractive energy option in the long term. The mission of the Fusion Energy Sciences program is to:

"Acquire the knowledge base needed for an economically and environmentally attractive fusion energy source."

This is a time of important progress and discovery in fusion research. The Fusion Energy Sciences program is making great progress in understanding turbulent losses of particles and energy across the magnetic field lines that are used to confine fusion fuels. In addition, the program is identifying and exploring innovative approaches to fusion power that may lead to less costly development paths.

Cross-cutting goals of the Fusion Energy Sciences program as developed through stakeholder meetings and endorsed by the Fusion Energy Sciences Advisory Committee are summarized below.

Understand the physics of plasmas, the fourth state of matter. Plasmas comprise most of the visible universe, both stellar and interstellar, and have many practical applications. Progress in plasma physics has been the prime engine driving progress in fusion research, and conversely, fusion energy has been the dominant motivation for plasma physics research.

Identify and explore innovative and cost-effective development paths to fusion energy. There is a continuous spectrum of approaches to fusion, from the tokamak, which is the leading reactor candidate, to other magnetic configurations to inertial confinement using particle beams or lasers. The current fusion program is encouraging both research on tokamak improvements and research on other innovative concepts.

Explore the science and technology of energy producing plasmas, the next frontier in fusion research, as a partner in an international effort. One of the strongest factors that favors fusion power is the potential for self-sustaining operation. Energy from the fusion reaction of deuterium and tritium is released in two components: 1) most of the energy released is in a form that can be extracted and used for commercial purposes; and 2) the remaining energy released is used to replace the energy losses of the confined plasma and to heat the deuterium and tritium sufficiently to sustain the fuel temperature and maintain the reaction process. When this replacement energy exceeds the energy losses, the fusion plasma is said to be "ignited." Understanding the physics of ignited, or self-heated plasmas and developing the technologies essential for fusion energy are linked goals that are achievable through the cooperative efforts of the world community. The long-term benefits to the United States of being a credible partner in this cooperative effort include ensuring our own scientific and technological integration in the world fusion program and contributing to a major step in the development of fusion as an energy source for a growing world population.

PERFORMANCE MEASURES:

The Fusion Energy Sciences program supports the Department's strategic goal of delivering the scientific and technology innovations critical to meeting the Nation's energy challenges. The performance measures of the Fusion Energy Sciences program fall into four areas: (1) excellence of the science, (2) relevance to the DOE mission and national needs, (3) stewardship of research capabilities, and (4) human resource management.

For FY 1999, specific performance measures are:

1. An independent assessment will judge Fusion Energy Sciences research programs to have high scientific quality.

2. Major operating experimental facilities will have research teams, which have participants from throughout the fusion science community. Assessments of research quality and program relevance will be provided to the performers by program advisory committees (PACs).

3. The National Spherical Torus Experiment (NSTX) project at Princeton Plasma Physics Laboratory (PPPL) will be completed and a national research team organized. The facility will begin experimental operations by the 3rd quarter of FY 1999 and the NSTX Program Advisory Committee (PAC) will provide guidance to PPPL for initial operations.

4. Theory and modeling efforts will result in state-of-the-art computational tools which are used to analyze experimental data and to suggest innovations. Standardized software and hardware configurations will be developed to allow national and international remote collaborations.

5. The Fusion Energy Sciences program will have a broadly based innovative concepts program including world-class experimental facilities integrated with theory and modeling.

6. The Technology program subelement will be restructured in FY 1999 to focus on domestic fusion program needs while maintaining strategic participation in international collaborative activities including appropriate participation in a restructured ITER project following completion of the current Engineering Design Activities.

SIGNIFICANT ACCOMPLISHMENTS AND PROGRAM SHIFTS

- A major phase of U.S. fusion research ended in April 1997 when the Tokamak Fusion Test Reactor (TFTR) at Princeton Plasma Physics Laboratory (PPPL) was shut down. Recent major accomplishments include: 1) creation of internal plasma thermal barriers that for brief pulses drastically reduce the loss of energy from the plasma core and confine particles and heat at theoretically ideal levels;
  2) confirmation of a new theory of plasma turbulence that explains important aspects of tokamak confinement; 3) discovery of a theoretically-predicted instability in tokamak plasmas that is driven by the fast alpha particles produced by the D-T fusion reactions; and 4) demonstration of operation with a high level of radiated power to lower the peak heat load on internal components. These last two accomplishments have provided valuable information for the design of future D-T fusion power systems--the alpha driven instabilities do not produce significant loss of alpha particles, and operation with a high fraction of radiated power is compatible with high fusion power performance. Over the 15-year lifetime of TFTR, many advances in fusion science and technology were achieved:

  -- Methods to employ tritium safely within a fusion powerplant environment were developed; and a million curies of tritium were safely processed.

  -- Over 10 million watts of fusion power were produced for the first time in a laboratory experiment, and numerous detailed measurements of the fusion reaction products were carried out;

-- 1 million amperes of electrical current were self-generated in the interior of the high temperature plasma as predicted by theory; and

-- 500 million degree Celsius plasmas were produced, far exceeding previous experiments.

- During FY 1997 the International Thermonuclear Experimental Reactor (ITER) Detailed Design Report was prepared by the international Joint Central Team, was reviewed by the four ITER Parties, and was accepted in July 1997 by the ITER Council, the governing board for ITER. Other major planned accomplishments are the scheduled completion of the Final Design Report in December 1997 and the completion of the current Engineering Design Activities (EDA) in July 1998.

- After completing its commitment to the 6-year EDA in FY 1998, and within the overall constraints on funding for Energy Research, the United States will aim to participate in strenghtened international collaboration on major fusion facilities abroad. To the extent that the ITER follow-on activities reflect the necessary restructuring, the U.S. would participate at a more modest level, integrated with other international activities, and in a manner which allows us to best exploit our investment in the EDA. In this case, the United States will continue to host the Joint Work Site in San Diego, and support reduced Joint Central Team and Home Team design efforts to take advantage of continuing ITER design, R&D, and other activities by the other parties. We will work with the ITER parties to attempt to arrange the test of the ITER superconducting model coil in order to confirm the design and establish operating margins to fully benefit from the $40,000,000 we have invested in building a major portion of the coil. The majority of closeout costs associated with those U.S. Joint Central Team members returning to their home institutions and reducing the Home Team design effort will be absorbed in FY 1998; however additional closeout funds will be needed in FY 1999. Since virtually all of the U.S. fusion program technology resources had been redirected to ITER during the EDA, resources in FY 1999 are identified to restore the base technology research effort with a focus on the needs of the U.S. domestic fusion program.

- Previous funding for ITER of $52,579,000 in FY 1998 is accounted for by a $1,496,000 reduction in the total fusion funding, and by a reallocation of the remaining $51,083,000 as follows:

PROGRAM MISSION - FUSION ENERGY SCIENCES (Cont'd)

Reallocation of Remaining ITER Program Funding
(B/A in millions)

	Change
Alcator C-Mod/DIII-D facility operations/research	+6.8
Alternate Concept experiments	+5.8
Theory	+1.7
Plasma Technologies	+16.1
Fusion Technologies	+5.5
Advanced Design	+15.2
	+51.0

- A large portion of the reallocated ITER funds has been allocated to the operation of DIII-D and C-MOD in order to ensure that the U.S. continues to have significant technical influence with the international fusion program in future years. Both Europe and Japan have strong tokamak programs in support of ITER. In concert with our international partners, the U.S. intends to contribute to the tokamak database and pursue tokamak improvements through increased operation of DIII-D and C-MOD. Similarly, the theory funding is increased to pursue increased understanding of fusion science. At the same time the funding shifted to alternate concepts will assure that the U.S. continues to play an important role in the evolution of fusion concept development over the longer term.

- Fundamental discovery and analysis have led to a remarkable new understanding of transport barriers, which reduce loss of energy from the core of a tokamak confined plasma. Energy transport refers to the loss of thermal energy (heat) from a fusion plasma. The rate at which heat is lost from the plasma determines the minimum size and cost of future fusion devices, such as ITER or a power plant. In a power plant, the reaction products must be confined well enough to replace energy losses so that the fusion reactions are self-sustaining (ignition) or very nearly so. A transport barrier is essentially an insulation layer in the plasma that significantly reduces the heat loss, resulting in very high central plasma temperatures. It is anticipated that such results will be applicable to other fusion approaches such as the innovative concepts that are the basis of the restructuring of the Fusion Energy Sciences program. These results mean that considerable progress has been achieved in the scientific understanding of the ultimate objective of developing simpler, more economical fusion power systems.

PROGRAM MISSION - FUSION ENERGY SCIENCES (Cont'd)

- A principal Fusion Energy Sciences Advisory Committee recommendation was to increase the U.S. effort in innovative concepts research. This budget increases funding for both the NSTX, an innovative new spherical torus experiment, as well as small-scale innovative concept experiments and plasma science experiments, all of which represents the leading edge of restructuring the fusion program. An important new facility, the NSTX, will begin operation in FY 1999. This proof-of-principle level facility will investigate the physics of the promising spherical torus concept. It will be located at PPPL but will be operated as a national collaborative experiment, with 50-60 scientists from 10-15 institutions expected to participate.

- Announcements of opportunities in plasma science in FY 1997 have resulted in new grants in two areas. Five Plasma Science Junior Faculty Development Program awards were made and new opportunities will be made available in FY 1999. More than 15 new awards in basic plasma science and engineering resulted from the new National Science Foundation (NSF)/DOE Joint Partnership in Plasma Science and Engineering.

- Based on technical peer review of 40 laboratory and university innovative concepts proposals, 3 new university scale experimental programs and 1 theoretical study began in FY 1998. These starts are consistent with the increased emphasis being given to alternative concepts in the restructured Fusion Energy Sciences program.

Funding of Contractor Security Clearances

- In FY 1999, the Department will divide the responsibility for obtaining and maintaining security clearances. The Office of Security Affairs, which has been responsible for funding all Federal and contractor employee clearances, will pay only for clearances of Federal employees, both at headquarters and the field. Program organizations will be responsible for contractor clearances, using program funds. This change in policy will enable program managers to make the decisions as to how many and what level clearances are necessary for effective program execution. In this way, it is hoped that any backlog of essential clearances which are impeding program success can be cleared up by those managers most directly involved. The Office of Energy Research is budgeting $115,000 for estimated contractor clearances in FY 1999 within this decision unit.

FUSION ENERGY SCIENCES
PROGRAM FUNDING PROFILE
(Dollars in thousands)

Subprogram	FY 1997 Current Appropriation		FY 1998 Original Appropriation		FY 1998 Adjustments		FY 1998 Current Appropriation		FY 1999 Request
Science	$94,750		$100,482		-$689	a/	$99,793		$110,460
Facility Operations	61,379		55,318		-180	a/	55,138		61,000
Technology	62,283		69,300		-1,475	a/	67,825		50,000
Program Direction	8,407		6,900		0	a/	6,900		6,700
Subtotal, Fusion Energy Sciences	226,819		232,000		-2,344	a/	229,656		228,160
Adjustment	0		-2,344	a/	2,344	a/	0		0
Adjustment	-2,069	b/	-668	c/	0		-668	c/	0
TOTAL, FES	$224,750	d/	$228,988		$0		$228,988		$228,160
Full-Time Equivalents	59		49		0		49		49

a/ Share of Energy Supply, Research and Development general reduction for contractor training.

b/ Share of Energy Supply, Research and Development general reduction for use of prior year balances assigned to this program ($2,069,000) and FY 1997 emergency flood supplemental recission ($64,000). The total general reduction is applied at the appropriation level.

c/ Share of Energy Supply, Research and Development general reduction for use of prior year balances assigned to this program. The total general reduction is applied at the appropriation level.

d/ Excludes $5,360,000 which has been transferred to the SBIR program and $321,000 which has been transferred to the STTR program.

Public Law Authorization:

Pub. Law 95-91, DOE Organization Act

FUSION ENERGY SCIENCES
(Dollars in thousands)

PROGRAM FUNDING BY SITE

Field Offices/Sites	FY 1997 Current Appropriation	FY 1998 Original Appropriation	FY 1998 Adjustments a/	FY 1998 Current Appropriation	FY 1999 Request
Albuquerque Operations Office					
Los Alamos National Laboratory	$ 3,643	$ 4,068	-$40	$ 4,028	$ 3,150
Sandia National Laboratories	5,266	5,605	-55	5,550	5,065
Chicago Operations Office					
Ames Laboratory	50	0	0	0	0
Argonne National Laboratory	2,480	2,875	-25	2,850	3,058
Brookhaven National Laboratory	60	50	0	50	0
Princeton Plasma Physics Laboratory	56,653	49,530	-495	49,035	49,495
Idaho Operations Office					
Idaho National Engineering Laboratory	2,360	4,110	-40	4,070	1,200
Oakland Operations Office					
Lawrence Berkeley National Laborator	11,553	4,240	-40	4,200	4,295
Lawrence Livermore National Laborat	9,064	10,478	-110	10,368	9,200
Stanford Linear Accelerator Center	50	50	0	50	50
Oak Ridge Operations Office					
Oak Ridge Institute for Science & Edu	949	825	0	825	0
Oak Ridge National Laboratory	17,049	17,772	-180	17,592	15,380
Richland Operations Office					
Pacific Northwest Laboratory	1,225	1,345	-15	1,330	1,474

Field Offices/Sites	FY 1997 Current Appropriation		FY 1998 Original Appropriation		FY 1998 Adjustments a/	FY 1998 Current Appropriation		FY 1999 Request
Savannah River Operations Office								
Savannah River Tech Center	395		452		0	452		0
All Other Sites	116,022		130,600		-1,344	129,256		135,793
Subtotal	226,819		232,000		-2,344	229,656		228,160
Adjustment	0		-2,344	a/	2,344	0		0
Adjustment	-2,069	b/	-668	c/	0	-668	c/	0
TOTAL	$224,750	d/	$228,988		$0	$228,988		$228,160

a/ Share of Energy Supply, Research and Development general reduction for contractor training.

b/ Share of Energy Supply, Research and Development general reduction for use of prior year balances assigned to this program ($2,069,000 and FY 1997 emergency flood supplemental recission ($64,000). The total general reduction is applied at the appropriation level.

c/ Share of Energy Supply, Research and Development general reduction for use of prior year balances assigned to this program. The total general reduction is applied at the appropriation level.

d/ Excludes $5,360,000 which has been transferred to the SBIR program and $321,000 which has been transferred to the STTR program.

FUSION ENERGY SCIENCES

SCIENCE

I. **Mission Supporting Goals and Objectives:** The goals of this subprogram are to advance plasma science, and to develop innovative approaches for confining a fusion plasma. This subprogram includes a modest program in basic plasma science; active research programs in both tokamak innovations and in non-tokamak concepts; focused efforts to resolve outstanding physics issues related to ITER and other energy producing plasmas; strong theory and modeling programs; and the creation of improved diagnostics that make possible rigorous testing of the scientific principles of fusion.

Plasma science is the study of the behavior of ionized states of matter–ranging from neon lights to stars–that make up 99 percent of the visible universe. It contributes not only to fusion research, but also to many national science and technology goals, ranging from astrophysics to industrial processing to national security. One objective of the Science subprogram is to broaden the intellectual and institutional base in fundamental plasma physics, and a joint NSF/DOE plasma science partnership made initial awards for research on important topics in plasma science and engineering in FY 1997.

Fusion energy research advances through a balanced combination of large-, medium-, and small-scale experiments, theory, and modeling. The largest component of the Science subprogram is the tokamak research activity, which focuses on gaining a predictive understanding of the behavior of plasmas in near reactor-level conditions where the fusion fuel begins to "burn". Tokamak research is carried out primarily on two major U.S. facilities (Alcator C-Mod at the Massachusetts Institute of Technology (MIT) and DIII-D at General Atomics (GA)), which are operated as national collaborative experiments, and through collaborations on large, state-of-the art facilities abroad. Increased collaboration on facilities such as JET and JT-60 was recommended by the Fusion Energy Science Advisory Committee. They also recommended that "in concert with our international partners, a burning plasma facility should be built at the earliest possible time." This goal is being pursued through the ITER collaboration where we expect to develop a broad range of options.

Research on alternative confinement concepts, both magnetic and inertial, is aimed at identifying approaches that may improve the economical and environmental attractiveness of fusion energy sources. This research is carried out at various levels ranging from the concept exploration stage to the proof-of-principle stage. Small-scale exploratory experiments are carried out primarily at universities, while proof-of-principle experiments, such as the NSTX will be carried out primarily at national laboratories.

The FES Inertial Fusion Energy (IFE) program is exploring an alternate path for fusion energy that would capitalize on the major R&D effort in inertial confinement fusion (ICF) for stockpile stewardship purposes within the Office of Defense Programs. The IFE program depends on the ICF program for experimental research into the physics of target ignition that will be tested in the National Ignition Facility at LLNL. Efforts in IFE focus on developing the most efficient methods for heating and compressing a target pellet to fusion conditions.

PROGRAM MISSION - SCIENCE (Cont’d)

Theory and modeling are important to progress in fusion and plasma science because they provide the capability to analyze existing experiments, produce new ideas to improve performance, and provide a scientific assessment of new ideas. An important component of the theory program is the development and use of computational tools to help understand the physical phenomena that govern confinement of high temperature plasmas. Similarly, the development and improvement of diagnostic tools for analyzing plasma behavior continues to provide new insights regarding fusion plasmas.

II. Funding Schedule:

Program Activity	FY 1997	FY 1998	FY 1999	$ Change	% Change	
Tokamak Experimental Research	$48,711	$48,227	$45,327	-$2,900	-6.0%	
Alternative Concept Experimental Research		16,436	23,545	34,060	+10,515	+44.7%
Theory	25,821	19,270	21,000	+1,730	+9.0%	
General Plasma Science	3,782	5,100	5,900	+800	+15.7%	
SBIR/STTR	0	3,651	4,173	+522	+14.3%	
Total Science	$94,750	$99,793	$ 110,460	+$10,667	+10.7%	

III. Performance Summary - Accomplishments	**FY 1997**	**FY 1998**	**FY 1999**
TOKAMAK EXPERIMENTAL RESEARCH	$48,711	$48,277	$45,327

Tokamak research focuses on developing the scientific foundations underlying the confinement of energetic plasmas and investigating improvements in tokamaks that could lead to a higher-performance, lower-cost tokamak fusion power plant. Key issues include reducing energy losses, increasing power density, maintaining the stability of a tokamak plasma, handling high heat loads, and optimizing all of the previous issues simultaneously in a high performance tokamak.

	FY 1997	FY 1998	FY 1999

To meet the challenge posed by the shutdown of the TFTR, U.S. fusion scientists and engineers are redefining their methods for carrying out fusion research. Both of the remaining large tokamak facilities (Alcator C-Mod and DIII-D) are becoming national collaborative experiments. Scientists from many institutions are working together on planning and carrying out experiments, many of them from their home institutions via internet connections.

Recent progress in the tokamak program includes: a basic understanding of how the loss of heat and particles can be dramatically reduced by the formation of barriers within the plasma; the development of operating techniques that reduce heat and particle contact with internal components; and the demonstration of advanced operating modes that can increase the power density of a tokamak plasma.

In addition to operating DIII-D and Alcator C-Mod, the program continues to support some innovative, small-scale tokamak experiments and develop advanced diagnostic instruments for studying high performance plasmas. Much of this work is conducted at leading universities. A competitive initiative to address new plasma diagnostic measurement techniques is planned.

International collaboration in tokamak research will be enhanced to take advantage of the unique experimental facilities that are available in Europe and Japan.

Education activities for improving science education for students and faculty in America’s schools, colleges and universities are also funded in this program.

	FY 1997	**FY 1998**	**FY 1999**
ALTERNATIVE CONCEPT EXPERIMENTAL RESEARCH	16,436	23,545	34,060

Research on magnetic confinement configurations other than the conventional tokamak is important both for its intrinsic scientific value and for its potential to discover concepts that would make attractive fusion power sources. Approximately 12 experimental programs, located primarily at universities, are currently supported. Some of those resulted from an FY 1998 innovative concept competition. Increased effort on these programs is planned for FY 1999.

The NSTX, located at PPPL, will begin operation in FY 1999. The NSTX research program will address fusion science issues such as current drive by radio waves, very high power density, and nearly total self-generation of the plasma current that helps to confine the plasma. This program will be organized as a national collaborative experiment. The conversion of a TFTR neutral beam heating system for reuse on NSTX will add significantly to NSTX heating and diagnostics capability when it is completed in FY 2000.

Preparations will begin for a second national proof-of-principle experiment using facilities and infrastructure available at PPPL. This would include national working groups selecting a candidate physics concept from ongoing smaller experiments and beginning pre-conceptual design.

In the area of IFE, research continues on ion beam drive methods and critical supporting technology issues. Steps to improve ion beam efficiency, ion accelerator components, and fusion chamber wall protection methods will be tested.

	FY 1997	FY 1998	FY 1999
THEORY	25,821	19,270	21,000

The theory program is an integral part of the Fusion Energy Sciences program and supports its mission in several ways: advancing basic theory of magnetically confined plasmas, producing new ideas to improve performance, supporting planning and interpretation of experiments in existing facilities, and helping to conceive and design future devices. The theory program will continue its advanced computing initiatives to develop new analysis codes and a code library for use by fusion researchers. Special emphasis will be placed on continued development of the tools needed for both national and international remote collaboration activities.

	FY 1997	FY 1998	FY 1999
GENERAL PLASMA SCIENCE	3,782	5,100	5,900

The plasma science program will continue to focus on basic plasma science and engineering research, primarily in the university community. Advances in basic plasma physics will support the Fusion Energy Sciences program as well as other important areas of science and technology. Funding for the Plasma Science Junior Faculty Development Program is increased and the NSF/DOE plasma science and engineering program will continue with modest growth over FY 1998 levels. The program will continue to compile atomic physics data for fusion.

FUSION ENERGY SCIENCES
SCIENCE

	FY 1997	FY 1998	FY 1999
SBIR/STTR FUNDING	0	3,651	4,173

In FY 1997, $3,630,000 and $218,000 were transferred to the SBIR and STTR programs, respectively. The FY 1998 and FY 1999 amounts are the estimated requirement for the continuation of these programs.

Total Science	$94,750	$99,793	$110,460

EXPLANATION OF FUNDING CHANGES FROM FY 1998 TO FY 1999:

Funding for TFTR is decreased primarily by reductions in personnel costs, following completion of the
-$6,415,000
TFTR physics program, placing it in a caretaker status, and redirecting the staff to other fusion research such as fabrication of the NSTX.

The DIII-D research funding is increased by $1,123,000 in order to improve the data analysis capability.
+$3,000,000
An increase in Alcator C-Mod of $1,200,000 supports added diagnostic development and data analysis efforts. An increase of $677,000 in International/other reflects greater support for U.S. scientists conducting experiments on unique foreign facilities, such as JET in Europe and JT-60U in Japan.

Beginning in FY 1999, this program will budget $115,000 for the estimated costs of obtaining and maintaining security clearances for contractor employees under the Chicago Operations Office and the Oak Ridge National Laboratory. +$115,000

Smaller scale tokamak experiments at universities and diagnostic development are increased, in part to
+$400,000

support a competitive initiative in advanced diagnostic development.

EXPLANATION OF FUNDING CHANGES FROM FY 1998 TO FY 1999 (Cont'd):

Support for NSTX is increased to begin research operations.	+$7,220,000
An increase is provided to initiate planning for and preliminary design of a second national proof-of-principle alternative concept using existing facilities ($2,200,000) at PPPL, as well as increased support for innovative concepts, primarily at universities.	+$3,295,000
An increase in fusion theory supports code development for national and international collaborative experiments.	+$1,730,000
Additional funding is provided for increasing the breadth of participation in the basic plasma science initiative that began in FY 1997.	+$800,000
SBIR/STTR funding is increased to provide required funding.	+$522,000
Total Funding Change, Science	+$10,667,000

FUSION ENERGY SCIENCES

FACILITY OPERATIONS

I. <u>Mission Supporting Goals and Objectives</u>: This activity provides for the operation of major experimental facilities that are the essential tools that enable scientists in university, industry, and laboratory based research groups to perform experimental research in fusion energy sciences. This subprogram includes funding for the operation and maintenance of the three major fusion research facilities: NSTX at PPPL, DIII-D at GA, and Alcator C-Mod at MIT. These facilities consist of magnetic plasma confinement devices, plasma heating and current drive systems, diagnostics and instrumentation, experimental areas, computing and computer networking facilities, and other auxiliary systems. It includes the cost of operating personnel, electric power, expendable supplies, replacement parts and subsystems, and inventories. In the case of PPPL, this funding also supports the safe shutdown and caretaking of TFTR, prior to removal from the site. General plant projects (GPP) funding for PPPL will be provided to support minor facility renovations, other capital alterations and additions, and for buildings and utility systems. Capital equipment funding for upgrading the research capability of DIII-D and C-Mod is also included, as are funds for design, fabrication, and installation of NSTX, and for further enhancements to the facility.

The principal objective of the Facility Operations subprogram is to maximize the quantity and quality of data collected for experiments being conducted at fusion energy sciences facilities.

The following table summarizes the scheduled weeks of operations for DIII-D and Alcator C-Mod. With the subsequent table on the next page, this table illustrates how the redirection of TFTR funds allows for increased operations of C-Mod and DIII-D (during FY 1998-1999) and beginning operations of NSTX in FY 1999.

Facility Utilization
(Weeks of Operation)

	FY 1997	FY 1998	FY 1999
DIII-D	8	13	14
Alcator C-Mod	8	11	18
TFTR	8	0 *	0 *
NSTX	0	0	6

*Facility shutdown.

FUSION ENERGY SCIENCES
FACILITY OPERATIONS

II. Funding Schedule:

Program Activity	FY 1997	FY 1998	FY 1999	$ Change	% Change
TFTR	$24,721	$5,090	$3,700	-$1,390	-27.3%
DIII-D	23,486	25,973	29,700	+3,727	+14.3%
Alcator C-Mod	7,540	9,315	10,100	+785	+8.4%
NSTX	5,032	13,860	16,800	+2,940	+21.2%
GPP	600	900	700	-200	-22.2%
Total Facility Operations	$61,379	$55,138	$61,000	+$5,862	+10.6%

III. Performance Summary - Accomplishments

	FY 1997	FY 1998	FY 1999
TFTR	$24,721	$5,090	$3,700

After termination of TFTR operations in FY 1997, these funds provide for maintenance and caretaking of the TFTR facility.

- -- FY 1997 - plasma operation using deuterium and deuterium-tritium fuel for 8 weeks; followed by safe shutdown and caretaking.
- -- FY 1998 - maintained in caretaking condition.
- -- FY 1999 - maintained in caretaking condition.

FUSION ENERGY SCIENCES
FACILITY OPERATIONS

	FY 1997	FY 1998	FY 1999
DIII-D	$23,486	$25,973	$29,700

Provides support for operation, maintenance, and improvement of the DIII-D facility, increasing the power available for DIII-D Electron Cyclotron Heating (ECH) systems and support for other equipment at the GA site.

- -- FY 1997 - plasma operation using hydrogen and deuterium fuel for 8 weeks; plus downtime for upgrades and maintenance.
- -- FY 1998 - plasma operation using hydrogen and deuterium fuel for approximately 13 weeks; plus downtime for upgrades and maintenance.
- -- FY 1999 - plasma operation using hydrogen and deuterium fuel for approximately 14 weeks; plus downtime for significant upgrades to the ECH and divertor systems and maintenance.

	FY 1997	FY 1998	FY 1999
ALCATOR C-MOD	7,540	9,315	10,100

Provides support for operation, maintenance, and improvement of the Alcator C-Mod facility, including adding diagnostic systems, and support for other equipment at the MIT site.

- -- FY 1997 - plasma operation using hydrogen and deuterium fuel for approximately 8 weeks plus downtime for maintenance.
- -- FY 1998 - plasma operation using hydrogen and deuterium fuel for approximately 11 weeks plus downtime for maintenance.
- -- FY 1999 - plasma operation using hydrogen and deuterium fuel for approximately 18 weeks plus downtime for maintenance.

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FACILITY OPERATIONS

	FY 1997	FY 1998	FY 1999
NSTX	5,032	13,860	16,800

Provides for completion of the NSTX project and for operation, maintenance, and improvement of the NSTX facility, supporting equipment at the PPPL site, and for initial operations beginning in late FY 1999. A planned equipment enhancement of NSTX includes adding an existing TFTR neutral beam heating system to the facility. This will enhance the initial capabilities of NSTX by increasing the heating and fueling flexibility, extending the performance of the machine, and providing more options for diagnosing the core plasma.

- -- FY 1997 - complete final design and start fabrication of components.
- -- FY 1998 - complete component fabrication and start assembly/installation.
- -- FY 1999 - complete assembly/installation, start operations; begin mods for an additional neutral beam.

	FY 1997	FY 1998	FY 1999
PPPL GENERAL PLANT PROJECTS	600	900	700

The maintenance of the laboratory physical plant is supported as needed to maintain the laboratory's physical plant (e.g., roof replacement, refurbishing office spaces, resurfacing sidewalks).

	FY 1997	FY 1998	FY 1999
Total Facility Operations	$61,379	$55,138	$61,000

FUSION ENERGY SCIENCES
FACILITY OPERATIONS

EXPLANATION OF FUNDING CHANGES FROM FY 1998 TO FY 1999:

A decrease for the TFTR at PPPL is due to reduced requirements for caretaking expenses.	-$1,390,000
The increase for DIII-D supports continuation of the upgrade of the DIII-D auxiliary heating systems.	+$3,727,000
The increase for Alcator C-Mod supports increased operations of the facility.	+$785,000
An increase in NSTX is provided for completion of fabrication and initiation of operations, as well as for beginning work on a neutral beam heating system for NSTX.	+$2,940,000
General Plant Projects support at PPPL is decreased.	-$200,000
Total Funding Change, Facility Operations	+$5,862,000

FUSION ENERGY SCIENCES

TECHNOLOGY

I. Mission Supporting Goals and Objectives: Most science-oriented programs, which continue to push the frontiers of human knowledge, require both intellectual resources and experimental facilities with state-of-the-art technological capabilities. The fusion program is a leading example of this dual resource need. The Technology subprogram develops the technological capabilities necessary for advancing both the science of fusion and of fusion energy, two strategic goals of the fusion program. Research, engineering, and advanced design will be performed in the areas of superconducting magnets, advanced heat removal methods, plasma diagnostics and control, plasma heating and fueling, safety, fuel processing and breeding, and high performance materials.

The Technology Program is divided into Fusion Energy Research and Advanced Materials. The largest Engineering Research subprogram element in FY 1998 was research and engineering design with the principal purpose of supporting the ITER program during the last year of the current ITER international agreement. The results of this work were also necessary for the viability of the base technology program. For FY 1999, the U.S. plan is to participate in restructured ITER follow on activities at a more modest level. The previous effort will be almost entirely redirected to support the U.S. domestic fusion program. In addition, an increased effort on technology support of major international facilities such as JET and JT-60 will begin. Much of the redirected effort will be dual-purpose, i.e., it will benefit the U.S. domestic fusion program as well as the restructured ITER. This will include the establishment of new initiatives in critical technology areas. The principal Engineering Research subprogram elements in FY 1999 are plasma and fusion technology research in support of existing domestic fusion facilities as well as technology research necessary to establish the knowledge base needed for an economically and environmentally attractive fusion energy source. Also, support will be provided for advanced design and assessments of critical aspects of integrated fusion systems.

The Materials Research subprogram element consists of research on low-activation materials and will be focused on high performance fusion system materials capable of withstanding long-term exposure to energetic particles and electromagnetic radiation from fusion plasma reactions.

II. Funding Schedule:

Program Activity	FY 1997	FY 1998	FY 1999	$ Change	% Change
Engineering Research	$56,336	$58,270	$42,485	-$15,785	- 27.1%
Materials Research	5,947	7,771	6,200	- 1,571	- 20.2%
SBIR/STTR	0	1,784	1,315	- 469	- 26.3%
Total Technology	$62,283	$67,825	$50,000	-$17,825	- 26.3%

III. Performance Summary - Accomplishments	**F**	**FY 1997**	**FY 1998**	**FY 1999**
ENGINEERING RESEARCH		$56,336	$58,270	$42,485

The U.S. plan for future participation in ITER activities is as follows. The current ITER Engineering Design Activities (EDA) will be completed in July 1998, and the expectation is high that the technical product of the EDA, namely, a design and supporting R&D information, would provide a satisfactory technical basis for making decisions to proceed with ITER construction. None of the ITER parties is yet prepared to offer to host the ITER construction project.

and interactions with the

Due to the critical importance of the ITER collaborative activity as a focus for the international effort to develop fusion as an attractive energy source free from greenhouse gas emissions and to accomplish useful science, the ITER Parties propose a 3-year post-EDA period between the end of the current EDA and an international decision on whether to construct ITER. In the U.S. view, the objective of this period will be to re-evaluate the technical objectives, and develop design options with their associated cost estimates to enable decisions on possible future construction by the end of the period. The principal activities of the post-EDA period, which will have a major impact on the construction decision, are site specific adaptations of the current ITER design regulatory authorities in those territories of Parties interested in hosting the ITER facility, namely the European Union, Japan and possibly Canada. As a requirement of our participation, another key task during the transition will be to find lower cost approaches to ITER; we see cost reduction as a key factor in enhancing the probability that ITER is built and, consequently, that U.S. fusion energy science objectives can then be met. A continuing ITER support activity will be collaborative experimental and theoretical fusion science research in existing fusion facilities world-wide. The ITER Director also proposes additional work during the transition, i.e. advance the design of all systems in order to improve the schedule during construction, conduct R&D tests on prototype components developed during the EDA in order to establish operating margins and initiate some new R&D.

After about two years of the transition, the ITER Parties would make an assessment of readiness to proceed with construction, taking into account progress on site specific design adaptations and regulatory interactions and the evaluation of the design options and cost estimates as well as prospects for sharing the cost of ITER construction, operation and decommissioning and for establishing a host site. If the assessment were positive, the Parties would proceed to make arrangements for a new construction Agreement to be signed at the end of the transition. If the assessment were negative, the ITER activities would likely be closed out by the end of the transition.

On the basis of strong favorable reviews from the President's Committee of Advisors on Science and Technology and the Fusion Energy Sciences Advisory Committee, the U.S. proposes to continue to participate in the ITER post-EDA period but at a level reduced from its current level in the EDA as would be appropriate for a Party not offering a candidate construction site.

FY 1997 . . . . **FY 1998 FY 1999**

The U.S. will participate in several design activities, i.e., support of the ITER Joint Work Site in San Diego, support a minimum number of scientists and engineers at the ITER joint work sites in technical areas where the U.S. has both interest and strong capability, and maintain a small Home Team design effort with a focus on design work associated with advanced modes of ITER operation and with possible lower cost configurations. In this way the U.S. will maintain an overall awareness of ITER follow on activities as a part of an integrated program of enhanced international activities.

Preserved from the ITER R&D and design activities conducted in earlier years will be personnel and facilities for technology

	FY 1997	**FY 1998**	**FY 1999**

R&D tasks at laboratories and universities to meet the needs of the U.S. fusion program. Some of these tasks will also benefit ITER and will be considered dual-purpose. These technology R&D tasks will be guided by peer review and community consensus for decisions affecting priorities and strategic planning. Merit review will be used extensively to achieve effective implementation of continuing tasks, and competitive processes will be used to select the most outstanding performers for new tasks.

For the nearer term needs of the fusion program, enabling technology work will be performed to meet the requirements of existing and planned plasma physics experiments, which will allow the program to fully exploit its investments in tokamak and alternate concept experiments. Component development and testing for plasma heating, plasma fueling, and plasma-facing systems, which build upon and extend state-of-the-art capabilities, will allow these experiments to operate at their limits for exploring the frontiers of fusion plasma science. Much of this work will also be applicable to ITER, i.e. dual-purpose.

	FY 1997	**FY 1998**	**FY 1999**

Technology support will also be performed in selected areas for the plasma physics experiments of our international partners in order to participate in their facilities and experimental programs. In addition, the extensive fusion safety expertise accumulated in the program will be applied toward achieving high standards in facility operation in FY 1999 and beyond.

For the longer term needs of the fusion program, advanced technology work will be aimed toward the program's mission-related goal of providing the technology knowledge base needed for an attractive fusion energy source. Testing will be conducted on the prototype of a major superconducting magnet component for a burning plasma experiment, which was fabricated jointly by the ITER parties with

U.S. leadership in the largest collaborative task of the ITER R&D effort. This testing will allow the program to capitalize on its substantial investment in magnet technology that is relevant to future U.S. fusion energy systems. In addition, initiatives will be implemented on two critical technology issues; research to establish the feasibility of innovative concepts for handling high surface heat fluxes and neutron wall loadings in burning plasma devices. This research is directed toward high-performance energy handling and extraction approaches that are generic to plasma confinement concepts and that will allow magnetic fusion to achieve its full potential as an attractive energy source.

Advanced design studies will be redirected to begin initiatives identifying an attractive pathway toward fusion energy that is based on (a) concept improvement and innovation in fusion plasma science and technology, (b) greater affordability than previous pathways, and (c) opportunities for applications of fusion energy that are nearer term than electricity generation.

	FY 1997	FY 1998	FY 1999
Efforts will be made to retain those U.S. scientists and engineers who participated in the ITER Joint Central Team and Home Team design activities and who possess the knowledge and skills that are vital to the U.S. domestic fusion program effort.			
Funding will also be needed for closeout costs to deal with ITER personnel who cannot be retained.			
MATERIALS RESEARCH	5,947	7,771	6,200

Materials research is a key element in developing safe, reliable and environmentally attractive fusion systems. Development and testing of vanadium alloys, silicon carbide composite materials and advanced ferritic steels for structural service in the high power zones of fusion power systems will continue. Priorities for this work, including innovative approaches to evaluating materials, will be guided by the results of a Fusion Energy Sciences Advisory Committee review to be conducted during FY 1998. Conceptual design of a fusion materials neutron source facility was completed in FY 1997 by an international team under the auspices of the International Energy Agency (IEA). U.S. involvement in the follow-on design and planning work is continuing at a low level in FY 1998. An initiative in advanced materials science will be implemented for development of computational models for predicting neutron interactive materials performance in fusion energy systems.

FUSION ENERGY SCIENCES
TECHNOLOGY

SBIR/STTR FUNDING	**FY 1997**	**FY 1998**	**FY 1999**
In FY 1997 $1,730,000 and $103,000 were transferred to the SBIR and STTR programs, respectively. The FY 1998 and FY 1999 amounts are the estimated requirement for the continuation of these programs.	$0	$1,784	$1,315
Total Technology	$62,283	$67,825	$50,000

EXPLANATION OF FUNDING CHANGES FROM FY 1998 TO FY 1999:

With the completing of the current ITER EDA activities in FY 1998, the U.S. role in the ITER transition period will be restructured with an accompanying redistribution of funds.	-$52,579,000
Plasma Technologies research, previously focused on ITER, is redirected to support U.S. fusion program domestic needs, including support for burning plasma physics objectives with initiatives in critical areas, much of which will also be applicable in ITER.	+$16,140,000
Fusion Technologies research, previously focused on ITER, is redirected to support U.S. fusion program domestic needs, including support for burning plasma physics objectives with initiatives in critical areas, much of which will also be applicable to ITER.	+$5,450,000
Advanced Design is increased in scope to support design work related to a restructured ITER and to investigate potential non-electric applications of fusion energy such as hydrogen production, and disposal of nuclear wastes and production of medical isotopes. Total funding for ITER joint baseline design will be $12,000,000.	+$15,204,000
SBIR/STTR funding is reduced due to fusion program reductions.	-$469,000

EXPLANATION OF FUNDING CHANGES FROM FY 1998 TO FY 1999 (cont'd):

	-$1,571,000
Support for advanced materials development is decreased primarily to reflect the completion of the fabrication of the fusion irradiation fixture originally funded by NE.	
Total Funding Change, Technology	+$17,825,000

FUSION ENERGY SCIENCES

PROGRAM DIRECTION

I. Mission Supporting Goals and Objectives: This subprogram provides the Federal staffing resources and associated funding needed to plan, direct, manage, and administer the highly complex scientific and technical research and development program in fusion energy. The Fusion Energy Sciences program is developing the magnetic and inertial approaches to attaining fusion energy as two separate and distinct programs, coordinating, on inertial fusion, with the Office of Defense Programs. International collaboration is an essential element of the program strategy and requires extensive coordination efforts.

In the request for Fusion Energy Sciences Program Direction, $500,000 has been included in FY 1998 for the Working Capital Fund and $373,000 in FY 1999 to cover the costs of centrally provided goods and services at Headquarters such as supplies, housing, utilities, etc..

II. Funding Table:

	FY 1997 Current Appropriation	FY 1998 Original Appropriation	FY 1998 Adjustments	FY 1998 Current Appropriation	FY 1999 Budget Request
Chicago					
Salary and Benefits	1,028	$910	$0	$910	$926
Travel	120	74	0	74	70
Support Services	0	0	0	0	0
Other Related Expenses	200	190	0	190	139
Total	1,348	$1,174	$0	$1,174	$1,135
Full-Time Equivalents	12	10	0	10	10
Oakland					
Salary and Benefits	174	$184	$0	$184	$189
Travel	14	14	0	14	14
Support Services	0	0	0	0	0
Other Related Expenses	2	2	0	2	2
Total	190	$200	$0	$200	$205
Full-Time Equivalents	2	2	0	2	2

FUSION ENERGY SCIENCES
PROGRAM DIRECTION

II. Funding Table (cont'd):

	FY 1997 Current Appropriation	FY 1998 Original Appropriation	FY 1998 Adjustments	FY 1998 Current Appropriation	FY 1999 Budget Request
Headquarters					
Salary and Benefits	4,783	$4,001	$0	$4,001	$4,084
Travel	250	225	0	225	200
Support Services	980	600	0	600	500
Other Related Expenses	856	700	0	700	576
Total	6,869	$5,526	$0	$5,526	$5,360
Full Time Equivalents	45	37	0	37	37
Total Fusion Energy Sciences					
Salary and Benefits	5,985	5,095	0	5,095	5,199
Travel	384	313	0	313	284
Support Services	980	600	0	600	500
Other Related Expenses	1,058	892	0	892	717
Grand Total	8,407	$6,900	$0	$6,900	$6,700
Full-Time Equivalents	59	49	0	49	49

FUSION ENERGY SCIENCES
PROGRAM DIRECTION

III. Performance Summary:

	FY 1997	FY 1998	FY 1999
Salaries and Benefits:	$5,985	$5,095	$5,199
Travel:	384	313	284
Support Services:	980	600	500

Salaries and Benefits:

In FY 1998 and FY 1999, the Fusion Energy Sciences program will operate in a downsized mode as a result of a major reduction in staffing in FY 1998, which is reflected in a substantial decrease in salaries and benefits in that year. Remaining staff will focus on the science and technology of fusion energy rather than on the development of a new energy system, in response to direction from Congress and the recommendations of the Fusion Energy Sciences Advisory Committee regarding reorientation of the Fusion Energy Sciences program.

Travel:

Further decreases in travel will be attained in FY 1998 and FY 1999 despite anticipated increases in the costs of airfare, lodging, etc. Alternatives to travel, such as teleconferencing, will be pursued where possible. Continued international travel will be required to reap the benefits of international cooperative programs, which comprise an important element of the program's strategic plan.

Support Services:

FY 1998 and FY 1999 requests provide the minimum level of support services needed to provide for the program's mailroom, travel processing, technical support and information systems development needs. Energy Research has the best record in the Department for judicious use of support services contracts.

FUSION ENERGY SCIENCES
PROGRAM DIRECTION

	FY 1997	FY 1998	FY 1999
Other Related Expenses:			
The estimates for FY 1998 and FY 1999 include $500,000 and $373,000, respectively, for the new Headquarters Working Capital Fund. The remaining funds cover computer hardware and software acquisitions for information architecture enhancements to permit network upgrades and corporate systems development, as well as rent and utilities, printing and training for field staff supported in this decision unit.	1,058	892	717
TOTAL PROGRAM DIRECTION	$8,407	$6,900	$6,700

FUSION ENERGY SCIENCES
PROGRAM DIRECTION

EXPLANATION OF FUNDING CHANGES FROM FY 1998 TO FY 1999:

Increase of $104,000 in Salary and Benefits resulting from the impact of general pay increases, promotions, and within grade increases.	$+104,000
Decrease of $29,000 in travel is due to increased use of alternatives to travel and the impact of staff downsizing.	$-29,000
Decrease of $100,000 in support services results from realization of savings associated with the overall downsizing of the Fusion Energy Sciences program.	$-100,000
Decrease of $175,000 for other related expenses is due to savings from FY 1998 downsizing, which are partially offset by the inclusion of training and printing costs for field staff.	$-175,000
Total Funding Change, Program Direction	$-200,000

FUSION ENERGY SCIENCES
PROGRAM DIRECTION

Support Services	FY 1997 ($000)	FY 1998 ($000)	FY 1999 ($000)	FY 1999/ FY 1998 Change ($000)
Technical Support Service				
Feasibility of Design Considerations				
Economic and Environmental Analysis				
Test and Evaluation Studies				
Subtotal				
Management Support Services				
Management Studies				
Training and Education	10	5	5	0
ADP Support	520	245	205	-40
Administrative Support Services	450	350	290	-60
Subtotal	980	600	500	-100
Total Support Services	980	600	500	-100
Use of Prior Year Balances				

FUSION ENERGY SCIENCES
PROGRAM DIRECTION

Other Related Expenses	**FY 1997 ($000)**	**FY 1998 ($000)**	**FY 1999 ($000)**	**FY 1999/ FY 1998 Change ($000)**
Training			11	+11
Working Capital Fund	600	500	373	-127
Printing and Reproduction			9	+9
Rental Space/Utilities	30	26	26	0
Software Procurement/Maintenance Activities/Capital Acquisitions	428	366	298	-68
Other				
Total Obligational Authority	1,058	892	717	-175
Use of Prior-Year Balances				
Total Budget Authority	1,058	892	717	-175

FUSION ENERGY SCIENCES CAPITAL OPERATING EXPENSES AND CONSTRUCTION SUMMARY
(Tabular dollars in thousands, narrative in whole dollars)

	FY 1997	FY 1998	FY 1999	$ Change	% Change
Capital Operating Expenses					
General Plant Projects (total)	600	900	700	-200	-22.2%
Capital Equipment (total)	6,543	16,097	13,700	-2,397	-14.9%

Major Items of Equipment (CE $2 Million and Above)

	TEC	Previous Approp.	FY 1997 Approp.	FY 1998 Approp.	FY 1999 Request	Acceptance Date
1. DIII-D Upgrade	32,400		15,975	2,250	2,440	2,700
2002						
2. NSTX	21,100	0	3,550	12,080	5,450	1999
3. NSTX - Neutral Beam	6,000	0	0	0	3,450	2000