DEPARTMENT OF ENERGY
FY 1995 CONGRESSIONAL BUDGET REQUEST
ENERGY SUPPLY, RESEARCH AND DEVELOPMENT

OVERVIEW

FUSION ENERGY

Fusion offers the promise of a safe, environmentally acceptable, inexhaustible and competitively-priced source of energy. Given that the nation will need new sources of energy in the next century, a goal-oriented fusion development program can make a meaningful contribution to the nation's energy prospects. The Administration has recognized the potential of fusion. President Clinton's "A Vision of Change for America" states that "...fusion offers the promise of abundant energy from readily available fuels with low environmental impact...." Further, the Fusion Energy program is clearly one that is appropriate for public support given that its funding needs are too great for individual firms to bear and that returns on investments are too distant to support private investments. Fusion Energy offers an unprecedented opportunity for large scale international collaboration in science and technology and is becoming a model for other international programs. Widespread uncertainty about the availability of safe and secure energy options and about public acceptance of major technologies capable of generating central station electricity dictates the continuation of efforts world-wide to develop fusion. A vigorous development program is required over the next several decades to confirm the promise of fusion.

The Department considers fusion to be an important source of electricity-generating capacity. The overarching goal of the program is to demonstrate that fusion energy is a technically and economically viable energy source. To achieve this goal, the program is expected to include an operating Demonstration Power Plant leading to an operating commercial plant. In order to ensure the economic success of fusion, the program focus is to study and develop the most effective confinement systems and technology, and to develop advanced materials suitable for fusion power plant environments. However, budgetary constraints over the past few years may mean that the schedule for meeting such objectives is delayed.

A broad international consensus now exists on how ignition and burn of a magnetically confined fusion plasma (i.e., the fusion fuel) can be achieved, and significant progress has been made toward this goal. To date, the most effective way to confine a plasma magnetically is to use a toroidal, or doughnut-shaped, device called a tokamak. Recent results indicate that the Tokamak Fusion Test Reactor in the U.S. and the Joint European Torus in the European Community are close to "breakeven" plasma conditions, a major goal whereby the energy produced by the fuel itself would equal the input energy applied to heat the fuel. During the next decade, the program will focus on demonstrating the scientific and technological feasibility of fusion in the International Thermonuclear Experimental Reactor project and on constructing the Tokamak Physics Experiment to study ways of making fusion power plants more compact and economical. In recent years there have been numerous physics and technology accomplishments in the Magnetic Fusion Energy program, including:

(1) the start of deuterium-tritium experiments in TFTR, and the achievement for the first time, of over 6 million watts of fusion power in December 1993;

(2) increase in the plasma pressure characteristics to levels adequate for an economic fusion reactor;

(3) encouraging tests showing that internally self-generated electric currents can be used to sustain the tokamak plasma for steady-state operation;

(4) production of higher pressure plasma conditions with lower external magnetic fields, that could improve the efficiency of a tokamak reactor;

(5) development of radiofrequency wave heating allowing high-power, localized heating of a tokamak reactor;

(6) development of improved fueling and impurity control techniques that will increase experimental reactor performance;

(7) successful tests of scale-model superconducting coils with magnetic field strength approximately in the range required for a fusion reactor;

(8) demonstration of safe handling techniques for the fusion fuel, tritium, at the Tritium Systems Test Assembly;

(9) completion of the conceptual design for the International Thermonuclear Experimental Reactor (ITER) by a joint U.S., European Community, Russian Federation and Japanese design team which is a model of successful international collaboration on a large scientific project;

(10) initiation of the next phase, the engineering design, of the ITER project by the four international parties, and;

(11) completion of the conceptual design of the Tokamak Physics Experiment (TPX) facility.

The scientific and technological issues that must be addressed to achieve the program's goals are ignition physics, fusion nuclear technology, magnetic confinement configuration optimization and low activation materials development. The U.S. fusion program is addressing these issues with the minimum number of devices and with a maximum degree of international collaboration, as exemplified by the joint ITER efforts referred to above. Additional issues of steady-state plasma control and advanced plasma performance, needed for an improved demonstration power plant, will be addressed by the Tokamak Physics Experiment. This is planned to be the next major U.S. experimental tokamak.

There are four main elements in the magnetic fusion program. The first element is the introduction of a fuel mixture of deuterium and tritium in the TFTR at the Princeton Plasma Physics Laboratory (PPPL). The introduction of deuterium-tritium (D-T) fuel has significantly increased the amount of energy obtained from the fusion reactions over previous experiments using only deuterium fuel, and has verified the extrapolations that have been made from non-tritium fusion experiments. The goal is to produce about 10 million watts of fusion power for about one second before the completion of the experiment at the end of FY 1994. This will make TFTR the first tokamak to perform extensive D-T experiments to provide important data on internally generated heat required. This information is needed for self-sustained fusion for future development steps such as ITER. The second major program element is ITER. The U.S. has, with the European Community, Japan, and the Soviet Union (now the Russian Federation), completed a three-year ITER conceptual design. ITER is intended to demonstrate the scientific and technological feasibility of fusion power. An agreement to proceed with the ITER Engineering Design Activities collaboration was signed in July, 1992, by all four parties. ITER is being designed to produce more than 1,000 MW of fusion power, under ignition conditions, and serve as the test bed for fusion technology in support of a Demonstration Power Plant. The third element is TPX, a proposed long pulse, advanced tokamak device that will make use of the TFTR test cell and existing equipment at the PPPL site in order to reduce the cost of the experiment. The TPX facility would seek to significantly improve the physics results of current tokamaks by exploring advanced operating modes with the potential for better confinement conditions, higher pressure limits, and efficient steady-state current drive. The final element is a base program of fundamental physics and technology research required to support ITER, TPX, and a demonstration power plant. It includes, for example, the DIII-D and Alcator C-Mod tokamaks, fusion theory and modeling, and the low activation materials development program.

The TPX would be a unique facility in the world with the capability to operate for long pulses and to develop advanced tokamak operating modes that could lead to a cost-effective, more efficient, and therefore a more attractive demonstration reactor. With the capability for long-pulse steady-state operation, the TPX would incorporate the mission envisioned for the Steady-State Experiment that is identified in the Energy Policy Act of 1992. The TPX would also enjoy a productive synergism with ITER. It would be the first tokamak in the world to use a fully superconducting magnet set in the geometry similar to that planned for ITER. It would benefit the planned ITER R&D and contribute valuable information for the nuclear testing phase of ITER, which requires steady-state operation. The project would represent a new level of investment by the fusion program in high technology industries and would enhance the transfer of fusion technologies into the commercial sector of the economy. It would also help prepare U.S. industry to play a meaningful role in the ITER project.

In the Inertial Fusion Energy (IFE) program, the objective is to develop components, such as a high-efficiency, high-repetition-rate driver and targets and reactor concepts that will use the target physics developed by the Department's Defense Programs Office. Activities will include continuation of the heavy ion accelerator research program. In addition, research will address target design features of high gain and ease of production that are unique to energy applications.

The budget request is $372,563,000 for Fusion Energy. The budget provides funding to analyze the data from the D-T experiments in TFTR and to assure the facility is maintained in a safe condition while preparations for decontamination and decommissioning efforts are made. In addition, support is provided for the U.S. portion of the ITER Engineering Design Activities requirements. Funding for construction of TPX is provided to develop tokamak improvements to increase the attractiveness of a post-ITER fusion reactor. This project is included in the President's investment package and would be operational in early 2000. Some hardware modifications will be provided for the DIII-D to upgrade its capability to address key issues in support of ITER and next generation machines. The base physics program, which includes theory and small scale experiments, will provide limited support for both ITER and tokamak improvement efforts. Increased support is provided to address the critical issue of materials development for future fusion devices.

Performance measures for the Fusion Energy program for FY 1995 are as follows:

1. Meet International Thermonuclear Experimental Reactor commitments and participate in the Joint Central Team design co-center activities.

    a. Number of task agreements executed: 15
    b. Number of Joint Central Team members assigned: 38

2. Meet 4 milestones for constructing the Tokamak Physics Experiment facility.

3. Meet 15 milestones consistent with the Energy Policy Act of 1992.

4. Transfer fusion technology to industry via 19 contracts with industry.

DEPARTMENT OF ENERGY
FY 1995 CONGRESSIONAL BUDGET REQUEST
ENERGY SUPPLY RESEARCH AND DEVELOPMENT
(Tabular dollars in thousands. Narrative in whole dollars.)

LEAD TABLE

Fusion Energy

Activity	FY 1993 Adjusted		FY 1994 Appropriation	FY 1994 Adjustment	FY 1995 Request
Operating Expenses					
Confinement Systems	$171,400		$170,400	-$2,237	$150,506
Applied Plasma Physics	61,860		59,805	-798	54,275
Development & Technology	66,400		81,300	-958	89,026
Planning & Projects	238	a/	4,895	0	5,857
Inertial Fusion Energy	8,150		4,000	-23	6,000
Program Direction	8,800		9,200	0	9,600
Subtotal Operating Expenses	316,848		329,600	-4,016	315,264
Capital Equipment	14,100		15,995	0	10,299
Construction	4,200		2,000	0	47,000
Subtotal	335,148		347,595	-4,016	372,563
Adjustment	-8,488	b/	0	0	0
Total	$326,660		$347,595	-$4,016	$372,563

a/ Excludes $4,562,000 which has been transferred to the SBIR program.
b/ Amount of general reduction assigned to this program will be taken at the Appropriation level.

	FY 1993 Adjusted	FY 1994 Appropriation	FY 1994 Adjustment	FY 1995 Request
Operating Expenses	$316,848	$329,600	-$4,016	$315,264
Capital Equipment	14,100	15,995	0	10,299
Construction	4,200	2,000	0	47,000
Subtotal Program	335,148	347,595	-4,016	372,563
Adjustment	-8,488	0	0	0
Total Program	$326,660	$347,595	-$4,016	$372,563
Staffing (FTEs)				
Headquarters	63	62	0	61
Field Office	19	21	0	21
Total	82	83	0	82

Authorization: Section 209, P.L. 95-91, "Department of Energy Organization Act"

DEPARTMENT OF ENERGY
FY 1995 CONGRESSIONAL BUDGET REQUEST
ENERGY SUPPLY RESEARCH AND DEVELOPMENT
(dollars in thousands)

SUMMARY OF CHANGES

Fusion Energy

FY 1994 Request	$ 347,595
- Adjustment	- 4,016
FY 1994 Adjusted	$ 343,579

Operating Expenses

Confinement Systems .... - 17,657

Supports continued operation of DIII-D and Alcator C-Mod. ATF will be shutdown indefinitely. Princeton Beta Experiment-M operation will return to limited operation in FY 1995. TFTR experiments are completed and the device will be maintained in a safe condition while decontamination and decommissioning activities begin. Princeton scientific and technical staff will be involved in data analysis of D-T experiments as well as off-site collaborations. R&D in support of the Tokamak Physics Experiment (TPX) design effort is provided.

Applied Plasma Physics .... - 4,732

Theory, diagnostic development, computer facility support and small university experiments are funded at slightly below the FY 1994 level with the primary focus on supporting ITER and TPX. Additional funds are provided to enhance local computing capabilities.

Development and Technology .... + 8,684

This increase provides for the support of U.S. share of the ITER Engineering Design Activities including the engineering design and technology development tasks required to validate the ITER design and for development of low activation materials.

Planning and Projects..	+ 962
Provides primarily for SBIR obligations.	
Inertial Fusion Energy..	+ 2,023
Activities are redirected as a consequence of the decision to defer consideration of construction of the accelerator for Induction Linac System Experiments (ILSE).	
Program Direction..	+ 400
Funds are provided to support the staffing resources associated with the Fusion Energy Program.	
Capital Equipment..	- 5,696
A decrease in capital equipment funds is primarily associated with a decision to proceed with a significantly descoped version of the equipment upgrades on the D-III-D facility.	
Construction..	+ 45,000
The increase is associated with the initiation of A-E design on the Tokamak Physics Experiment (TPX).	
FY 1995 Congressional Request..	$372,563

KEY ACTIVITY SUMMARY

FUSION ENERGY

I. Preface: Magnetic Fusion Energy - Confinement Systems

The Confinement Systems subprogram supports the goals of the Department's Magnetic Fusion Energy Program through the completion of deuterium-tritium (D-T) fusion experiments in the Tokamak Fusion Test Reactor (TFTR) at the Princeton plasma Physics Laboratory (PPPL), carrying out research to resolve the key scientific issues of magnetic fusion, planning for major facilities to improve the tokamak concept, and conducting physics R&D for the International Thermonuclear Experimental Reactor (ITER). The goal of operating a demonstration power plant requires a detailed understanding of how to heat, confine, and control a D-T plasma. Research supported by the Confinement Systems subprogram is devoted to providing this understanding by studying the properties of reactor-like toroidal plasmas with sophisticated diagnostics, comparing experimental data with theoretical models, and using the results to define new experiments on existing devices or to guide the design of new devices, if needed, to complete the scientific data base. The key scientific issues being addressed by this research are energy confinement; plasma heating; equilibrium and stability; power handling and particle control; current drive; and alpha particle physics.

Energy confinement is perhaps the most important physics issue affecting the performance of future fusion research devices, such as ITER and TPX. In a fusion reactor, the plasma must be heated to a temperature of about 100,000,000 degrees Celsius to initiate the fusion reactions, and then the thermal energy of the plasma must be sufficiently well confined that the heat from alpha particles (helium nuclei) created in the deuterium and tritium reaction sustains the plasma temperature. Research on energy confinement and plasma heating involves developing and using external heating systems, such as neutral beams and/or radio-frequency (RF) waves, to heat a plasma to high temperatures. Diagnostics and plasma control techniques are used to characterize, understand, and determine how to reduce energy loss from a high-temperature plasma. Energy confinement research in support of future experiments is being carried out in close cooperation with experimental and theory groups supported by the Applied Plasma Physics subprogram.

The most critical design issue for next generation devices such as ITER and TPX is power handling and particle control, which is closely coupled both to physics and technology issues. Both alpha particles (helium nuclei) and very high levels of power, each generated by the fusion reaction, need to be exhausted from the vessel, and the plasma fuel has to be replenished. High power on surrounding surfaces can dislodge impurities, which migrate to the plasma core and both dilute the fuel and cool the plasma by radiation. Therefore, physics and technology efforts are needed to develop methods to carry away the plasma power with minimal impurity generation. Furthermore, this power exhaust system has to be compatible with removal of the leftover alpha particles. Studies are being conducted in developing better power exhaust and particle control systems (such as magnetic divertors), in understanding impurity migration to the plasma core, and in developing plasma fueling by injection of high-velocity frozen hydrogen or deuterium pellets.

In a practical fusion power reactor, the temperature and density of the plasma (i.e. the plasma pressure) must be high enough to produce sufficient fusion power to make an economical reactor. In order to do this, an external magnetic field must apply a pressure about 10 times larger than the pressure of the plasma for stable containment of the plasma. Since practical magnets have technological limits on the pressure they can exert, research on equilibrium and stability is concentrated on creating alternate plasma shapes and operating conditions that theory predicts can increase the ratio of plasma pressure to the confining magnetic field pressure (the ratio is referred to as beta). Research to date has shown that D-shaped plasmas can achieve a sufficiently high beta value to meet the design objectives of ITER. This work also includes research on obtaining a predicted so-called "second regime of stability" of the plasma, which results in even higher beta values than can be obtained in the present operating mode. If successful, operation in this regime could lead to more compact and cheaper reactors.

The current drive physics issue addresses the future operation of fusion devices in a continuous, or steady-state, mode as opposed to the present short pulses where the current is driven inductively by an external winding. The primary advantage of steady-state operation is that it will reduce the problems of thermal and mechanical fatigue of components. Planned experiments include attempts to drive currents in tokamaks with radio-frequency waves and with current-carrying elements inserted at the plasma edge. Current drive experiments are important to ITER, which will require improved current drive in its enhanced phase.

The behavior of alpha particles in a confined plasma is the major physics issue that needs to be addressed to understand and control a burning plasma. The impact of alpha particle heating on energy confinement and plasma stability is a subject of critical importance to assessing the potential of magnetic fusion as an energy source. Work on this issue is being addressed in TFTR during its period of deuterium-tritium operation and subsequently studied in detail in ITER.

The major goal of the U.S. Magnetic Fusion Energy program is to develop fusion reactors as a technically and economically credible energy source for the 21st century. Improvements in tokamak operation could provide enhanced performance and lead to the cost reduction of tokamak power reactors. The construction of a new facility, the Tokamak Physics Experiment (TPX), will have the principle mission of studying advanced tokamak physics in steady-state operating conditions. It is being designed to develop optimized steady-state operating modes. Steady-state operation in TPX will also provide valuable information for the nuclear testing phase of ITER. The FY 1995 request includes $66.9 million ($21.9 million of operating funds) to begin construction of TPX as part of the President's FY 1994 Economic Investment package.

Because of their unique capabilities, several toroidal magnetic confinement devices are being used to investigate the scientific issues discussed above and to prepare for the burning plasma physics experiment on ITER. Analysis of the data from the D-T experiments on TFTR will provide information on the behavior of D-T plasmas and alpha particle physics. Experiments on confinement, beta limits, power and particle control, and current drive will be carried out on the DIII-D tokamak at General Atomics (GA). Research at the Alcator C-Mod tokamak at the Massachusetts Institute of Technology will be focused on the power and particle control with an ITER-like configuration, radio-frequency heating, and confinement in a high-field, high-density plasma.

The Confinement Systems budget permits only limited research on existing advanced toroidal devices. The Princeton Beta Experiment at PPPL is able to study advanced physics operation in support of TPX using its capabilities to control plasma current and pressure profiles. PBX-M carried a limited number of experiments in FY 1992-1993, and is currently shut down so that PPPL can focus its limited resources on the completion and analysis of the TFTR D-T experiments. To minimize funding requirements, PBX-M will not begin operation until mid-1995. The Advanced Toroidal Facility at the Oak Ridge National Laboratory (ORNL), an alternate configuration to a tokamak, was shut down in FY 1993 and will be run briefly in FY 1994 to study long pulse, low power operation. Because of overall federal budget constraints, this experiment will be permanently closed out at the end of FY 1994.

The number of fusion facilities is diminishing as the program continues to consolidate with program focus on ITER, TPX, and other high priority issues. The scientific staff at universities and laboratories with no operating facilities are being encouraged to apply their knowledge and skills to the remaining tokamaks through collaborative programs. Lawrence Livermore National Laboratory and Oak Ridge National Laboratory scientists and engineers will continue major collaborations on DIII-D at General Atomic and support the national effort on TPX. Scientists from the TFTR program will begin collaborative activities on other experiments when they have completed analysis of the TFTR results. Joint experiments will be continued on TEXTOR and ASDEX-Upgrade in Germany, TORE SUPRA in France, the Joint European Torus (JET) in England, and JFT-2M and JT-60-Upgrade in Japan.

The following table summarizes the operating expense funding the Confinement Systems subprogram:

II. A. Summary Table: Magnetic Fusion Energy - Confinement Systems

Program Activity	FY 1993 Enacted	FY 1994 Enacted	FY 1995 Request	% Change
Tokamak Fusion Test Reactor (TFTR).............	$ 78,905	$ 75,441	$ 51,100	- 32
Base Toroidal.................................	66,645	66,221	67,306	+ 2
Advanced Toroidal.............................	13,352	7,241	10,200	+ 41
Tokamak Physics Experiment (TPX)...............	12,498	19,260	21,900	+ 14
Total, Magnetic Fusion Energy - Confinement Systems	$ 171,400	$ 168,163	$ 150,506	- 10

II. B. Major Laboratory and Facility Funding

LAWRENCE LIVERMORE NATIONAL LAB	$ 4,899	$ 4,469	$ 4,200	- 6
OAK RIDGE NATIONAL LAB	$ 11,675	$ 10,649	$ 8,631	- 19
PRINCETON PLASMA PHYSICS LAB	$ 92,376	$ 95,500	$ 79,975	- 16

III. Activity Descriptions: (New BA in thousands of dollars)

Program Activity	FY 1993	FY 1994	FY 1995
Magnetic Fusion Energy - Confinement Systems			
Tokamak Fusion Test Reactor (TFTR)	TFTR shut down November 1, 1992, to complete the modifications required for D-T operation. Major modifications included: installation of shielding for diagnostics, final commissioning of the tritium systems, installation of tritium monitors and safety equipment, modification of the neutral beam systems to operate with tritium, and final adjustment of new diagnostics to monitor the alpha particles. First operations with the modified systems occurred in June, 1993. Following a thorough review of procedures and safety systems, D-T experiments began in November, 1993.	TFTR will make an important contribution to the study of burning plasmas as it carries out its full D-T program. The major elements of the program include: experiments on confinement properties and heating of D-T plasmas, the effect of alpha particles on the plasma, experience with the technology of large fusion-related systems, and a demonstration of 10 MW of fusion power production. These results will be timely and useful for the ITER Engineering Design Activities. Work will begin on planning and preparing for decontamination and decommissioning of TFTR so that the facility may be used for TPX.	Following the completion of the deuterium-tritium (D-T) experiments, there will be four major activities. The first is data analysis and the reporting of the results of the first extensive program of D-T experiments in a tokamak. The second is the safe shutdown of the TFTR facility and the removal of diagnostics and data acquisition equipment not needed for the Tokamak Physics Experiment. The third is the decontamination and decommissioning of the TFTR equipment in the test cell to make it available for TPX. The fourth is the initiation of an off-site collaboration program with other U.S. and foreign laboratories. This program will use the core scientific and technical staff

Program Activity	FY 1993	FY 1994	FY 1995
Tokamak Fusion Test Reactor (TFTR) (Cont'd)			to continue work on critical physics and technology issues for ITER and a demonstration reactor.
	$ 78,905	$ 75,441	$ 51,100
Base Toroidal	For DIII-D, the Ion Cyclotron Range of Frequencies (ICRF) power increase from 2 MW to 6 MW was begun. Experiments using this system to test fast wave current drive for ITER is in progress, beginning at the 2 MW level. Advanced divertor operation with a new cryo-pump is being evaluated as a first step in developing the radiative divertor concept. Experiments on high stability limits with good confinement are continuing with further improvements in current profile control. ORNL collaboration is continuing in RF and divertor pumping and the LLNL collaboration is being expanded in divertor and advanced tokamak areas.	For DIII-D, the 6 MW ICRF system will be completed and design of an ITER-relevant radiative divertor will be initiated. Current drive experiments will continue with higher power, as well as exploration of ICRF heating techniques. Advanced Tokamak studies will emphasize configuration compatibility with the radiative divertor design. ORNL and LLNL collaborations will continue.	At DIII-D, the 2 MW 100 GHz ECH system will be completed. Current drive experiments will continue with higher power Electron Cyclotron Heating (ECH) and ICRF heating techniques with an emphasis on profile control for long pulses. A pellet injector will be installed to enhance the particle control program. ORNL and LLNL collaboration will continue.
	Alcator C-MOD coil repairs were completed and the machine began plasma operations. The first phase of experimental operation was successfully completed, with up to 1 MA of plasma current and nearly 1 MW of radio wave power injected into the plasma.	ICRF heating experiments on Alcator C-MOD will be increased to the 4 MW level. Evaluation of confinement conditions in high density, high magnetic field regime will be carried out. Vacuum vessel wall coating studies and plasma impurity transport investigations will be continued. Studies of highly elongated plasma shapes and the effects of high power heating on plasma stability will begin. Divertor studies in support of ITER will also begin.	For Alcator C-MOD, full 9T magnetic field operation is planned with plasma currents up to 2.5 MA. Divertor studies in support of ITER will be the highest priority. These will include the exploration of several operating modes as well as a power and particle handling comparison between open and closed divertors (as planned for ITER). Studies of confinement in high field, high density plasmas will continue. A significant collaboration with the TFTR staff is planned, and preparation for the installation of an additional 2 MW of ICRF heating power will begin.

Program Activity	FY 1993	FY 1994	FY 1995
Base Toroidal (Cont'd)	There is no experimental activity at LLNL. Scientific staff has been redirected to support research on DIII-D.	No experimental activity at LLNL. Scientific staff will continue to support research on DIII-D.	No experimental activity at LLNL. Scientific staff will continue to support research on DIII-D.
	Efforts on international collaboration of several physics experiments will be decreased.	Collaborative experiments on plasma edge physics, particle control, fueling, heating, current drive, and confinement will be continued on modified TEXTOR, ASDEX-U, and TORE SUPRA (with long pulses) in support of ITER; JET collaboration will be resumed with the completion of the JET pumped divertor. Physics design analyses and physics R&D coordination in support of ITER will be continued.	Collaborative experiments on plasma edge physics, particle control, fueling, heating, current drive, and confinement will be continued on modified TEXTOR, ASDEX-U, and TORE SUPRA (with long pulses) in support of ITER; JET collaboration will be resumed with the completion of the JET pumped divertor. Physics design analyses and physics R&D coordination in support of ITER will be continued.
	$ 66,645	$ 66,221	$ 67,306
Advanced Toroidal	ATF shutdown is continuing, but reassembly of ATF has begun. Modest repairs to the helical magnet coil were made. Collaborative activities on DIII-D, TFTR, and PBX-M continued with scientific personnel from ATF.	ATF reassembly will be completed and limited operations will be carried out before the machine is shut down to accommodate funding reductions. Collaborative activities on DIII-D and TFTR will continue.	The ATF experiment will be closed down indefinitely. Collaborative activities on DIII-D and TFTR will continue.
	PBX-M operation was suspended for about 6 months due to funding limitations at PPPL. Experimental operation later in the year focused on techniques of current profile control in support of TPX.	PBX operated briefly. PBX-M will be shut down in FY 1994. The core staff will be reassigned to support TFTR and PPPL collaborative activities.	PBX-M will return to operation in mid-FY 1995. Experiments will focus on current profile and other advanced tokamak techniques in support of TPX.
	$ 13,352	$ 7,241	$ 10,200

III. Magnetic Fusion Energy - Confinement Systems (Cont'd):

Program Activity	FY 1993	FY 1994	FY 1995
Tokamak Physics Experiment (TPX)	Conceptual design and R&D in support of the Tokamak Physics Experiment (TPX) will be continued in preparation for an international review and a cost validation in the spring of 1993. The preparation of an Environmental Assessment to determine whether an Environmental Impact Statement is required will also be completed.	A national effort will proceed with preliminary design of the TPX to address the scientific issues associated with improving post-ITER reactor concepts. Major phased industrial contracts will be competitively awarded for design with options for fabrication of the superconducting magnets, vacuum vessel, plasma facing components, system integration and construction management. R&D will be conducted for technology development, prototyping, and mockup testing to support the design process.	Preparations for construction of TPX, the principal U.S. initiative to address scientific improvement for post-ITER reactor concepts, will continue. Design and R&D efforts by the TPX national project team will intensify, and fully integrate efforts of the major industry subcontractors. Preliminary design will be completed and work will proceed into detailed design for all systems. R&D will involve prototyping magnet coils, a vacuum vessel segment, divertor components, and building mockups for in-vessel remote maintenance testing. Refurbishment of existing equipment and facilities at PPPL will begin, and the Safety Analysis Report will be completed. The remaining $45 million is included under the construction section of the budget.
	$ 12,498	$ 19,260	$ 21,900
Magnetic Fusion Energy - Confinement Systems	$ 171,400	$ 168,163	$ 150,506

KEY ACTIVITY SUMMARY

FUSION ENERGY

I. Preface: Magnetic Fusion Energy - Applied Plasma Physics

The Applied Plasma Physics subprogram supports research to improve understanding of fusion physics principles and to investigate innovative techniques leading to improved plasma confinement conditions. These activities are selected to support program goals for ITER and the design of reactor concepts. This subprogram includes experimental plasma research and fusion energy theory and computing. The complex behavior of a plasma determines the physical size, magnetic field and current needed for tokamak devices to achieve net energy release. Applied Plasma Physics supports research on basic magnetic confinement physics and supplements research performed in the Confinement Systems subprogram by developing new diagnostic systems, plasma heating and control concepts, and basic data necessary to design and conduct the fusion energy program's major experiments. Activities include: theoretical and experimental physics, analysis and design supporting major devices, and computing support.

In 1989, a tokamak transport initiative was begun to improve understanding of how energy and particles are lost from the plasma by mechanisms that "transport" them across magnetic fields that confine the plasma. A significant portion of the Applied Plasma Physics activity has been focused on this issue. The improved understanding of transport physics together with the advent of massively parallel computers allows the development of theories to simulate what is happening inside the tokamak. A multi-year effort to develop this computational capability became a focus of the program in late FY 1992. During FY 1995, new predictive codes will be tested for their ability to simulate transitions that occur in tokamaks to improved plasma operating conditions through modification of external influences such as applied electric and magnetic field perturbations, plasma heating, and current drive controls. The codes will be tested in comparison with tokamaks such as DIII-D and TEXT. The aims are to improve predictive design of TPX in the near term and in the longer term to simulate performance of ITER and provide tools for design of a demonstration power plant.

Theoretical activities will further support ITER through: analyses of containment and thermalization of fast alpha particles produced in fusion burning, modeling of methods to control large scale plasma instabilities and impurities, and simulation of the heat flow at the plasma edge and to divertor surfaces. In addition, general models of plasma behavior will be developed for different confinement geometries. This theory work uses both analytical and numerical techniques and is performed at universities, national laboratories, and industrial research centers.

The Experimental Plasma Research activity supports the development of experimental techniques, basic data, and fundamental physics information required to operate and interpret present major confinement experiments. Most of the Experimental Plasma Research activities are conducted by universities, with some by national laboratories and industry as well. Several university programs are carried out using small scale toroidal devices which exploit different magnetic configurations including tokamaks, stellarators, and reversed field pinches. In FY 1995, specialized diagnostic equipment will be operated to measure properties of energy and particle transport at the TEXT, DIII-D, and C-Mod tokamaks. New diagnostics for measuring alpha particle distribution and associated physics effects will be supported at TFTR and JET. Diagnostic systems for ITER will be conceived and tests to qualify diagnostic components for ITER will be initiated. The TEXT tokamak at the University of Texas, Austin, will be operated with electron cyclotron heating and divertors in order to compare transport of particles and energy in various tokamak operation modes. Atomic data necessary for understanding plasma behavior will be obtained and compiled in cooperation with the International Atomic Energy Agency with direct application to ITER needs. Innovation to seek improved, reactor-relevant features will continue. Methods of injecting small plasmoids to fuel large tokamaks will be prepared for larger scale tests. New current drive and stability control techniques, that will have received small scale tests, will be evaluated. Three exploratory experiments were initiated in FY 1993 to test, at small scale, non-toroidal confinement concepts that could lead to reactors much different and smaller than tokamaks. These different approaches, along with unconventional toroidal confinement methods, will be evaluated toward the end of FY 1995.

The Office of Scientific Computing provides access to major state-of-the-art computational hardware for the fusion energy program. The Energy Sciences Network and related computing facilities support the development of models and codes, plasma theory, management and interpretation of fusion experimental results, and the design of large scale fusion experiments. The network infrastructure links the major Energy Research computers at LLNL, ORNL, and LANL to six fusion-supported user service centers at General Atomics, PPPL, ORNL, LANL, LLNL, and MIT. International data links and telephone lines also provide access to other users. In FY 1994, improved computer network access will be installed to couple the ITER design site at San Diego more effectively with other U.S. and international fusion research centers. The integration and extension of codes for tokamak simulation using new massively parallel computers will be supported. This budget also includes $700,000 in FY 1994 and FY 1995 in support of the FCCSET Education Activities. Computing funds included here will enhance local and distributed computing at fusion sites and implement and maintain user infrastructure for access to the major computers.

II. A. Summary Table: Magnetic Fusion Energy - Applied Plasma Physics

Program Activity	FY 1993 Enacted	FY 1994 Enacted	FY 1995 Request	% Change
Fusion Plasma Theory............................	$ 19,586	$ 18,491	$ 17,100	- 8
Experimental Plasma Research....................	26,769	25,892	24,025	- 7
MFE Computing..................................	15,505	14,624	13,150	- 10
Total, Magnetic Fusion Energy - Applied Plasma Physics	$ 61,860	$ 59,007	$ 54,275	- 8

II. B. Major Laboratory and Facility Funding

LAWRENCE LIVERMORE NATIONAL LAB	$ 15,255	$ 12,894	$ 11,804	- 8
LOS ALAMOS NATIONAL LABORATORY	$ 2,795	$ 2,370	$ 2,236	- 6
OAK RIDGE NATIONAL LAB	$ 4,355	$ 3,803	$ 3,853	+ 1
PRINCETON PLASMA PHYSICS LAB	$ 4,200	$ 3,306	$ 3,245	- 2

III. Activity Descriptions: (New BA in thousands of dollars)

Program Activity	FY 1993	FY 1994	FY 1995
Magnetic Fusion Energy - Applied Plasma Physics			
Fusion Plasma Theory	Maintain emphasis on improved understanding of the transport process in toroidal devices. Deploy and evaluate the impact of new techniques for data analysis and for visualization of toroidal plasma models. Develop models for stabilization of small-scale instabilities in burning plasmas.	Maintain emphasis on improved understanding of transport in toroidal devices. Provide codes to interpret and help plan D-T experiments in TFTR. Make use of massively parallel computers to run the codes to provide the necessary detail of stability and transport in the presence of significant alpha particle populations.	Maintain emphasis on improved understanding of transport in toroidal devices. Make use of insights developed through the Transport Initiative and the Numerical Tokamak to produce models of transport due to small-scale turbulence and compare the results with data from operating devices.
	Continue theory development in support of ITER with emphasis on alpha particle stability and transport. Develop realistic models for RF heating and profile control. Provide models for transport of heat and particles in magnetic divertors.	Continue development and application of theory to ITER design, with particular emphasis on alpha particle effects on stability of the plasma, physics of the plasma edge and divertor, and use of RF for auxiliary heating, current drive, and profile control.	Continue theory support of ITER design activities. Deploy more realistic codes of plasma edge and divertor operation in support of the engineering design of particle control for ITER. Apply magnetohydrodynamic codes to the study of disruption in TPX and ITER, and explore new techniques like neural networks for the design of disruption control systems.
	Maintain contact with foreign alternate concept theory programs and apply alternate concept developments related to tokamak improvement ideas.	Maintain contact with foreign alternate concept programs and apply ideas developed in alternate magnetic geometries to the improvement of tokamak operations.	Maintain contact with foreign alternate concept programs and apply ideas developed in alternate magnetic geometries to the improvement of tokamak operations.
	$ 19,586	$ 18,491	$ 17,100

III. Magnetic Fusion Energy - Applied Plasma Physics (Cont'd):

Program Activity	FY 1993	FY 1994	FY 1995
Experimental Plasma Research	Evaluate RF method of helicity injection current drive. Construct laboratory scale multi-pulse compact toroid injector. Continue studies of low aspect ratio (spherical) and high aspect ratio tokamaks. Operate low aspect ratio tokamaks at PPPL and the University of Washington.	Continue physics studies of low aspect ratio tokamak at PPPL and high aspect ratio tokamak at Columbia. Complete detailed studies of compact toroid injection physics at UC Davis. Evaluate RF current drive at frequencies below the ion cyclotron frequency at the University of Wisconsin.	Continue physics studies of the low aspect ratio tokamak at PPPL and the high aspect ratio tokamak at Columbia to improve physics understanding of the tokamak. Slow evaluation of requirements for a test of compact toroid injection for central core fueling on a major tokamak. Extend prospects for steady-state tokamaks by completing studies of RF current drive at frequencies below the ion cyclotron frequency at the University of Wisconsin.
	Complete device modification and initiate studies of transport mechanisms at the TEXT Upgrade tokamak using a new higher energy heavy ion beam probe and related diagnostics in electron cyclotron heated plasmas.	Continue studies of transport mechanisms in TEXT Upgrade using a new energy heavy ion beam probe and related diagnostics in electron cyclotron heated plasmas.	Continue studies of transport mechanisms in TEXT Upgrade to various confinement modes using the new heavy ion beam probe and related diagnostics in plasmas. Delay implementation of higher levels of electron cyclotron heating.
	Continue proof-of-principle tests for alpha particle diagnostic systems. Enhance efforts to adapt advanced diagnostics to ITER, focusing on the impact of harsh radiation and temperature environment.	Perform proof-of-principle tests for alpha particle diagnostic systems in a D-T plasma on TFTR. Participate in planning for advanced diagnostics to be included on ITER and emphasize development of ITER relevant diagnostics.	Complete proof-of-principle tests for alpha particle diagnostic systems in a D-T plasma on TFTR. Continue development of selected advanced diagnostic concepts and components for applications in ITER.
	Continue basic experiments in a small stellarator, a reversed field pinch, and tokamaks with emphasis on tokamak improvements. Initiate small-scale experiments on new concepts for more attractive reactors. Initiate construction of the helically symmetric stellarator plasma system at the University of Wisconsin.	Evaluate plasma characteristics of reversed field pinch to tokamak transition region at the University of Wisconsin. Begin initial compact toroid acceleration experiments at the University of Washington. Continue construction of helically symmetric plasma system at the University of Wisconsin. Carry out small scale experiments on new concepts for more attractive reactors.	Measure transport for different operating modes ranging from reversed field pinch to tokamak to improve understanding of operating mode options for tokamaks at the University of Wisconsin. Evaluate accelerated compact toroid configurations as reactor fueling concept at the University of Washington. Continue construction of helically symmetric plasma system at the University of Wisconsin for physics test of a non-tokamak reactor concept. Evaluate the small scale exploration of new concepts.

Program Activity	FY 1993	FY 1994	FY 1995
Experimental Plasma Research (Cont'd)	Continue plasma edge physics and core fluctuation measurements related to the transport process on major tokamaks using advanced diagnostics and collaborations. Initiate construction of edge physics data base.	Continue selected edge physics and core fluctuation measurements related to transport on major tokamaks using advanced diagnostics. Expand edge physics data base to include high confinement data through coordination with existing efforts.	Continue selected edge physics and core fluctuation measurements related to transport on major tokamaks using advanced diagnostics to extend understanding and simulation of tokamak performance. Expand edge physics data base to include high confinement data through coordination with existing efforts.
	Extend excitation and ionization measurements of impurities found in the plasma, including ITER specific applications. Extend atomic data compilation, under international guidelines, to support design of ITER edge plasma control techniques.	Complete selected excitation and ionization measurements for impurity ions, including ITER specific applications. Extend atomic data compilation, under international guidelines, to support design of ITER edge plasma control techniques. Provide specific data and atomic rates for divertor modeling and simulation.	Extend excitation and ionization measurements for impurity ions, with focus on atomic processes specified for ITER. Extend atomic data compilation, under international guidelines, to support design of ITER edge plasma control techniques. Provide specific data and atomic rates for divertor modeling and simulation.
	$ 26,769	$ 25,892	$ 24,025
MFE Computing	Support access to Energy Science Network and primary Energy Research computers. Provide local computers at fusion sites. Support specific computer code developments in new high performance computers for tokamak simulation.	Support access to Energy Science Network and primary Energy Research computers. Provide local computers at fusion sites. Support specific computer code developments using new high performance computers for tokamak simulation.	Support access to Energy Research computers. Prototype distributed computing implementations to improve remote collaborative and remote experimental activities. Support specific code development to use emerging high performance computing for tokamak simulation.
	$ 15,505	$ 14,624	$ 13,150
Magnetic Fusion Energy - Applied Plasma Physics	$ 61,860	$ 59,007	$ 54,275

DEPARTMENT OF ENERGY
FY 1995 CONGRESSIONAL BUDGET REQUEST
ENERGY SUPPLY, RESEARCH AND DEVELOPMENT
(dollars in thousands)

KEY ACTIVITY SUMMARY

FUSION ENERGY

I. Preface: Magnetic Fusion Energy - Development and Technology

The Development and Technology subprogram supports: the design and technology development for the International Thermonuclear Experimental Reactor (ITER); the development of the technologies needed for the Tokamak Physics Experiment, D-III-D and other present and future fusion experiments; and studies of future fusion systems. The work is divided into three main technical areas: ITER, Plasma Technologies, and Fusion Technologies.

The U.S. has committed to be an equal partner with the European Community, Japan and the Russian Federation in the 6-year ITER Engineering Design Activity (EDA). The overall objectives of ITER are to demonstrate the scientific and technological feasibility of fusion power, to demonstrate controlled ignition and extended burn, and to validate design concepts and qualify engineering components for a fusion reactor. The ITER EDA consists of the engineering design of the ITER device and the physics and technology development tasks required to validate and confirm the ITER design. The EDA began in the summer of 1992, with the signing of a formal agreement by the four parties on July 21, 1992. The Development and Technology subprogram includes funding for the U.S.'s share of ITER design and development work. Theory and diagnostics support for ITER are covered in the Applied Plasma Physics subprogram. Experimental tokamak physics support is provided by the Confinement Systems program. One of the goals of the EDA effort is to involve U.S. industrial firms so that they will be able to compete for contracts to fabricate components and systems of the ITER device in the event that it is decided at a later date to construct ITER. U.S. industrial firms have been integrated into the U.S. effort in order to provide expertise in large project management, systems design and integration, scale-model components and specific technology development tasks. The technology development tasks selected for emphasis in FY 1995 will be a continuation of those assigned by and negotiated with the ITER Director and approved by the ITER Council in FY 1994.

The Plasma Technologies activity develops the technologies needed to form, confine, heat and sustain a reacting fusion plasma. These technologies include magnetic systems, plasma heating systems, fueling systems and materials in the plasma environment. The general focus of these activities is ITER, although development in support of existing and near term devices, such as D-III-D and TPX, is specifically addressed. The principal activity in the magnetic systems program is to develop reliable high field pulsed and steady state superconducting magnets that provide the magnetic field conditions required to confine the plasma. The ITER superconducting magnets require significant development and demonstration of the technology of large, high field superconducting magnets. The heating program focuses on developing the technologies required to heat the plasma ions and electrons to reactive conditions and to sustain a steady-state plasma current needed for long-term confinement of the plasma. It encompasses electromagnetic wave heating methods using electron cyclotron heating and ion cyclotron heating techniques. The plasma fueling program develops high speed deuterium and tritium pellet injectors not only to maintain the proper amount of plasma fuel, but also to tailor the plasma density profiles for optimum performance. Use of developed heating and fueling systems directly supports the operating magnetic confinement experiments and has enabled the production of record plasma conditions in fusion devices. Plasma Materials Interaction (PMI) research is continuing for low and high atomic number (Z) materials that would provide the capability to withstand higher heat flux and plasma erosion for the first wall and divertor components. PMI research focuses on examining erosion and redeposition in present tokamaks, as well as tritium retention and release. Several of these U.S. technologies provide the basis for many existing international collaborative programs. Projected experiments in higher density and higher temperature plasmas of extended duration will necessitate continued development of higher power, longer pulse length, and higher frequency electromagnetic wave sources, transmission components, improved fueling devices, and plasma facing materials.

The Fusion Technologies activity focuses on materials development and long-term waste issues, safety features, environmental considerations, component reliability, tritium fuel breeding/processing, and power extraction. These elements are important for future fusion power reactors, as well as ITER and TPX. These activities relate to fuel cycle, blanket and nuclear data; materials development and irradiation; scoping studies of a high energy neutron irradiation facility; and environment and safety. Ongoing tasks relating to blankets and nuclear data include examination and design of the tritium breeding blanket for ITER and cooperative work under both the auspices of the International Energy Agency (IEA) and two U.S./Japan bilateral agreements; one on blanket engineering and the other on the Tritium Systems Test Assembly (TSTA) experimental tritium processing research. Materials development and irradiation supports examinations of proposed ITER structural materials, low activation materials for future applications, and divertor materials. In addition, there is ongoing research on future fusion structural materials via cooperative agreements with Japan and the Russian Federation and through multilateral agreements under IEA auspices. Environment and safety research emphasizes the operation of all the fusion reactor components and systems in a safe and environmentally acceptable way. Emphasis today is being placed on studying the radioactivity hazards associated with fusion reactors.

The Fusion Systems Studies activity supports studies using analytical and computational tools as well as data from the ongoing fusion program to model future fusion systems, to identify potential problem areas, and to provide future program directions. The Advanced Reactor Innovative Engineering Studies (ARIES) has been completed. Follow-on studies to define a demonstration reactor, which would follow ITER, have started. A stellarator reactor design study has been initiated and will continue into FY 1994.

Some of the significant facilities utilized in the Development and Technology subprogram include: the FENIX Test Facility at the Lawrence Livermore National Laboratory for testing of superconducting magnets; the Plasma Materials Test Facility at Sandia National Laboratories; the RF Test Facility at Oak Ridge National Laboratory; and a megawatt gyrotron test facility at VARIAN. The Tritium Systems Test Assembly (TSTA) at Los Alamos National Laboratory and the fusion materials work in the High Flux Isotopes Reactor (HFIR) at Oak Ridge National Laboratory are also supported under collaborative agreements with Japan.

The FY 1995 budget request reflects the high priority given to supporting ITER and is summarized below.

II. A. Summary Table: Magnetic Fusion Energy - Development and Technology

Program Activity	FY 1993 Enacted	FY 1994 Enacted	FY 1995 Request	% Change
ITER	$ 48,136	$ 62,356	$ 68,600	+ 10
Plasma Technologies	6,012	5,848	5,300	- 9
Fusion Technologies	3,643	3,516	3,276	- 7
Fusion Systems Studies	3,010	2,884	2,500	- 13
Advanced Materials	5,599	5,738	9,350	+ 63
Total, Magnetic Fusion Energy - Development and Technology	$ 66,400	$ 80,342	$ 89,026	+ 11

II. B. Major Laboratory and Facility Funding

ARGONNE NATIONAL LAB (EAST)	$ 5,833	$ 5,169	$ 5,680	+ 10
LAWRENCE LIVERMORE NATIONAL LAB	$ 7,622	$ 8,682	$ 3,305	- 62
LOS ALAMOS NATIONAL LABORATORY	$ 3,684	$ 3,553	$ 3,540	0
OAK RIDGE NATIONAL LAB	$ 11,301	$ 11,956	$ 15,175	+ 27
PACIFIC NORTHWEST LAB	$ 3,356	$ 3,117	$ 3,425	+ 10
SANDIA NATIONAL LABORATORIES	$ 5,503	$ 5,325	$ 6,812	+ 28

III. Activity Descriptions: (New BA in thousands of dollars)

Program Activity	FY 1993	FY 1994	FY 1995
Magnetic Fusion Energy - Development and Technology			
ITER	In the magnet area, design and development of ITER model coils and preparations for test of these coils will continue. Preparation of U.S. Requests for Proposals for superconducting strand with ITER specifications will be completed. Component testing in FENIX will be continued.	In the magnet area, design and development of ITER model coils and preparations for testing of coil components and fabrication techniques will continue. U.S. testing of superconducting strand will continue. Testing of full size, short samples of U.S., Japanese and RF superconducting cable for ITER will begin. Structural material tests will continue.	In the magnet area, design and development of ITER model coils and preparations for testing of coil components and fabrication techniques will continue. U.S. testing of superconducting strand will continue, and preparation for cabling the strands in collaboration with the EC will begin. Testing of full size, short samples of U.S., Japanese and RF superconducting cable for ITER will continue in FENIX. Structural material tests will continue.
	In the heating area, development of a negative ion source and accelerator for ITER will proceed, and preparation of testing facilities for these components will continue. Development of gyrotron tubes and RF launchers will continue.	In the heating area, development of advanced RF launchers and gyrotron tubes and components for ITER will continue. Negative ion source and accelerator development toward concept validation will be terminated.	In the heating area, development of 1 MW, advanced gyrotron tube and components for ITER will continue.
	In the fueling area, development and fabrication of a high speed pellet injector to meet ITER needs will continue.	In the fueling area, development and fabrication of a high speed pellet injector to meet ITER needs will continue.	In the fueling area, development and fabrication of a high speed pellet injector to meet ITER needs will continue.
	In the area of plasma materials interaction, the reference ITER divertor concepts will be studied and evaluated; and tests will continue on beryllium, carbon and high Z materials. Erosion and redeposition and disruption simulation tests will continue.	In the area of plasma materials interaction, ITER divertor concepts will be refined and examined. Tests will continue on beryllium, carbon and high Z materials. Erosion, redeposition and disruption simulation tests will continue. ITER divertor-specific modelling will be continued.	In the area of plasma materials interaction, the ITER divertor concept will be developed and more fully tested, if possible. Tests will continue on beryllium, carbon and high Z materials. Irradiation of divertor materials will continue. Erosion, redeposition and disruption simulation tests will continue. ITER divertor-specific modelling will continue.

Program Activity	FY 1993	FY 1994	FY 1995
ITER (Cont'd)	Experimental evaluations of the ITER reference materials for first wall blanket/shield structures, divertor structures, heating, and diagnostic systems will address critical questions and contribute to the design data base work needed for ITER.	Tasks assigned to the U.S. on materials for first wall/blanket/shield and divertor will be conducted to fulfill ITER agreements. Tests include irradiation, compatibility, data base generation, and fabrication studies on austenitic stainless steels, vanadium alloys, copper alloys, niobium alloys, and/or other material classes.	U.S. tasks on structural materials will be conducted to fulfill ITER agreements. These will include irradiation tests, compatibility tests, compatibility studies, data base generation, and fabrication studies on material classes of interest to ITER.
	The scope of blanket work is expanded to study feasibility issues of all candidate ITER design concepts. Liquid metal cooling options for ITER are supported with experimental studies of insulator coatings and magnetohydrodynamics effects. An industrial contract was awarded for sub-scale model testing.	Conduct U.S. task assignments for ITER blanket/shield R&D program, including initial phases of non-nuclear thermo-mechanical and thermal hydraulic testing of sub-scale blanket/shield prototypic modules and of nuclear testing with neutronic mock-ups exposed to a small 14 MeV neutron source in Japan.	Conduct medium-scale thermo-mechanical testing of ITER blankets and shield prototype modules, including tests of performance limits and off-normal response. Begin intermediate scale neutronics testing to determine shielding effectiveness, activation, and nuclear heating characteristics of blanket and shield.
	Operate Tritium Systems Test Assembly (TSTA) to provide data for and validation of an improved ITER fuel cycle design.	Conduct U.S. task assignments in TSTA to provide data base for and validation of ITER fuel cycle design, performance validation and safety analysis.	Conduct U.S. task assignments in TSTA to provide data base for and validation of ITER fuel cycle design, performance validation and safety analysis.
	The ITER funded environment and safety work will support developing the regulatory-quality safety data base required for ITER. Details of the design will be examined as they are developed with a focus of making the design safe.	The magnetic fusion program will continue to evaluate and support improving the safety of ITER with regard to activation products, confinement, and tritium safety. An integrated failure data base and design standards will also be developed.	The magnetic fusion program will continue to evaluate and support improving the safety of ITER with regard to activation products, confinement and tritium safety. An integrated failure rate data base and design standards will also need to be developed.

III. Magnetic Fusion Energy - Development and Technology (Cont'd):

Program Activity	FY 1993	FY 1994	FY 1995
ITER (Cont'd)	Assembly maintenance and containment structure tasks were initiated. Industrial contracts were awarded for R&D on remote welding and cutting operations, and for fabrication of an advanced doubled-wall vacuum vessel.	Conduct U.S. task assignments for ITER assembly/maintenance and containment structure R&D programs, including work under industrial contracts for vacuum vessel fabrication, attaching locks, vertical port assembly demonstration, and standard component and process development.	ITER Assembly/Maintenance work will focus on the design and fabrication of remote maintenance tooling and mockups for vertical port-remote handling procedures, and on component development leading to mockup testing of ICRF remote maintenance system. Containment structures work will focus on testing of prototype vacuum vessel structural joints and on testing of blanket attaching locks and supports.
	No activity.	U.S. assigned tasks on evaluation of the irradiation and service performance of ceramic and glass materials for use in diagnostic components will be conducted.	U.S. assigned tasks on evaluation of the irradiation and service performance of ceramic and glass materials for use in diagnostic systems will continue at ITER-specific conditions.
	Continue as full participant in the ITER design for the EDA on a four-party basis by providing staff to the central team and providing design support for assigned design tasks within the U.S. Provide for industrial participation in the design process to utilize industrial expertise within the ITER process and to qualify industry to participate in ITER construction if that were to follow the EDA.	Continue as full participant in the ITER design for the EDA on a four-party basis by providing staff to the central team and providing design support for assigned design tasks within the U.S. Provide for industrial participation in the design process to utilize industrial expertise within the ITER process and to qualify industry to participate in ITER construction if that were to follow the EDA.	Continue as full participant in the ITER design for the EDA on a four-party basis by providing staff to the central team and providing design support for assigned design tasks within the U.S. Utilize industrial expertise within the ITER design and R&D process and qualify industry to participate in ITER construction if that were to follow the EDA. Provide U.S. support for ITER joint fund.
	Provide for management of the U.S. ITER Home Team. Support operation of the San Diego ITER Co-Center.	Provide for management of the U.S. ITER Home Team. Support operation of the San Diego ITER Co-Center.	Provide for management of the U.S. ITER Home Team. Support operation of the San Diego ITER Co-Center.
	$ 48,136	$ 62,356	$ 68,600
Plasma Technologies	Superconducting wire characterization tests and magnet analysis will be conducted. Magnet insulator analyses will be initiated.	Superconducting wire characterization tests and magnet analysis will be conducted, and prototype conductors fabricated. Development support for TPX magnets will be provided.	Superconducting wire characterization tests and magnet analysis will be conducted, and prototype conductors fabricated. Development support for TPX magnets will be continued.

Program Activity	FY 1993	FY 1994	FY 1995
Plasma Technologies (Cont'd)	In the heating area, development of 110 GHz, 1 MW gyrotron tubes will be continued and design of internal coupler will be started. ICRH antenna design and development work will proceed in support of existing and near term fusion devices. Negative ion source development will continue.	In the heating area, fabrication of 1 MW, 110 GHz gyrotron tube with internal coupler will be completed. ICRH antenna design and development work will proceed in support of existing and near term fusion devices. Tests of a folded waveguide antenna on a tokamak will be initiated. Studies to determine heating requirements for TPX will be initiated. Negative ion source development will be terminated.	The completion of 1 MW, 110 GHz gyrotron will be delayed to FY 1996, and ICRH antenna design efforts in support of near term fusion research will be slowed down.
	Advanced high speed pellet injectors will be developed and tested.	Two stage high speed pellet injector development will be continued.	Two stage high speed pellet injectors will be developed.
	In the plasma materials interaction area, effort will be focused to provide tritium inventory support for TFTR and international collaborations.	In the plasma materials interaction area, effort will be focused on providing plasma facing component measurements of erosion in support of TPX and beryllium fabrication for international collaborations.	In the plasma materials interaction area, effort will be focused on providing plasma facing component measurements of erosion in support of TPX and beryllium fabrication for international collaborations.
	$ 6,012	$ 5,848	$ 5,300
Fusion Technologies	Conduct international cooperation on blanket research only in areas of critical feasibility issues for reactor-relevant blankets and for ITER blanket test modules. Conduct TSTA operations at a level needed to test high-leverage tritium processing systems components, and systems.	Continue international cooperative programs on U.S.-Japan testing of tritium fuel cycle components and system in TSTA, on U.S.-Russia-Germany testing of liquid metal magnetohydrodynamics concepts in the ALEX facility, and on U.S.-Japan-Canada-European Community test of ceramic tritium breeding materials.	Initiatives to conduct DEMO-relevant blanket testing under an IEA agreement will be terminated. There will be very limited preparation for ITER nuclear technology testing. Testing in TSTA will be reduced and focused on critical fuel cycle issues.

III. Magnetic Fusion Energy - Development and Technology (Cont'd):

Program Activity	FY 1993	FY 1994	FY 1995
Fusion Technologies (Cont'd)	The base environment and safety program will be focused on activation products and their release. There will be work on developing improved safety, economic and environmental codes. The base program will continue to develop the analytical tools (e.g. codes, models, etc.) that demonstrate the safety aspects of fusion facilities.	The safety and environment program will emphasize definition and safety characterization of low activation materials and attractive long-term technologies toward fusion safety and environmental potential. The other main thrust will be continuing development of safety analysis computer codes and associated data in activation products, tritium and off-normal plasma disruptions.	Safety analysis computer codes and activation product release experiments will be limited to immediate needs. Work for future guidance will not be carried out.
	$ 3,643	$ 3,516	$ 3,276
Fusion Systems Studies	Continue non-steady-state tokamak reactor study. Initiate stellarator reactor studies and tokamak demonstration powerplant study with enhanced industrial team involvement.	Complete study of stellarator reactor and continue demonstration powerplant requirements. Complete non-steady-state study.	System design of a power plant demo with industry is continued.
	$ 3,010	$ 2,884	$ 2,500
Advanced Materials	Materials for first wall/blanket/shield structures, for use in heating systems, divertor structures, and diagnostic systems will be under study. Modifications of compositions and microstructures to improve properties and to enhance resistance to irradiation will continue to be evaluated. Critical feasibility questions on use of silicon-carbide (SiC) composites will be investigated in limited experiments.	Structural materials for first wall/blanket/shield regions, divertor structures, and ceramics for insulating applications will continue under evaluation and development. Emphasis is on reduced activation materials meeting performance requirements with resistance to degradation under irradiation. Evaluation of vanadium and silicon carbide will be continued. Two collaborations with Japan will continue.	Structural materials and insulating ceramics will continue under evaluation for ITER and fusion reactors. The funds for experiments on reduced activation materials meeting performance requirements with resistance to degradation under irradiation will be used to explore ferritic steels, vanadium and silicon carbide. These materials will reduce radiative waste from a fusion reactor. Collaborations with Japan and Russia will continue.

Program Activity	FY 1993	FY 1994	FY 1995
Advanced Materials (Cont'd)	Scoping studies begun in FY 1992 will continue toward preliminary conceptual design of an accelerator-based neutron source large enough to meet international needs. Critical design issues related to accelerator components and target features will be explored. Collaborations with Japan and the EC will be developed.	Preconceptual design of a neutron source based on a linear accelerator beam of deuterons on a liquid lithium target will be completed. Activities will be integrated into an international program on neutron source development, under IEA, with Russian participation. Critical design and testing issues will be under investigation.	Preliminary design of a neutron source based on the deuterium lithium concept will be initiated with international partners, through IEA coordination.
	$ 5,599	$ 5,738	$ 9,350
Magnetic Fusion Energy - Development and Technology	$ 66,400	$ 80,342	$ 89,026

DEPARTMENT OF ENERGY
FY 1995 CONGRESSIONAL BUDGET REQUEST
ENERGY SUPPLY, RESEARCH AND DEVELOPMENT
(dollars in thousands)

KEY ACTIVITY SUMMARY

FUSION ENERGY

I. Preface: Planning and Projects

II. A. Summary Table: Planning and Projects

Program Activity	FY 1993 Enacted	FY 1994 Enacted	FY 1995 Request	% Change
Planning and Projects...........................	$ 238	$ 4,895	$ 5,857	+ 20
Total, Planning and Projects	$ 238	$ 4,895	$ 5,857	+ 20

III. Activity Descriptions: (New BA in thousands of dollars)

Program Activity	FY 1993	FY 1994	FY 1995
Planning and Projects	Funding in the amount of $5,562,000 has been transferred to the SBIR program.	Funding in the amount of $4,703,000 has been budgeted for the SBIR program.	Funding in the amount of $5,857,000 has been budgeted for the SBIR program. This amount will be reduced upon allocation of the productivity savings reflected in the lead table.
	$ 238	$ 4,895	$ 5,857
Planning and Projects	$ 238	$ 4,895	$ 5,857

DEPARTMENT OF ENERGY
FY 1995 CONGRESSIONAL BUDGET REQUEST
ENERGY SUPPLY, RESEARCH AND DEVELOPMENT
(dollars in thousands)

KEY ACTIVITY SUMMARY

FUSION ENERGY

I. Preface: Inertial Fusion Energy

Progress in inertial confinement fusion has provided confidence that net energy release in the laboratory is possible through compression, ignition, and burn of microcapsules of deuterium-tritium fuel. With this background, the Department of Energy has established this Inertial Fusion Energy (IFE) subprogram to develop the potential of inertial fusion as an energy source. This activity is managed within the Office of Energy Research as a separate component of the Office of Fusion Energy.

This activity will rely on coordination with Inertial Confinement Fusion in the Office of Defense Programs and has extended the Heavy Ion Fusion Accelerator Research that previously was undertaken within the Basic Energy Sciences subprogram of the Office of Energy Research. Inertial fusion is under development as a component of nuclear weapons research because it can test basic concepts of fusion explosions. The same basic concepts have potential for commercial energy applications. The target compression and ignition physics are central to the energy concept but will be developed under Defense Programs' activities. The heavy-ion driver is specifically needed for energy applications.

For commercial energy, a number of requirements must be met to deliver compression driving energy to the target at high efficiency and high repetition rate. For significant net energy production, the ignition and burn of a microcapsule is required to produce many times the energy required to compress the capsule. The compression driving source must have sufficient energy efficiency to allow net energy release from the system. For a reasonable energy source, the compression, ignition, and energy gain should be repeated several times each second. Thus, energy applications of inertial fusion require high-efficiency, high-repetition-rate drivers, targets that can reliably yield useful net energy gain that can be cheaply produced; and reactor chambers to contain the micro-explosions and convert energetic fusion products to electricity.

The development of a heavy-ion driver has been the primary activity under the Inertial Fusion Energy program and a research accelerator for Induction Linac System Experiments (ILSE) has been proposed and conceptual design prepared and reviewed. In May 1993, in response to the Department, the Fusion Energy Advisory Committee recommended embarking on a stronger heavy-ion inertial fusion energy program with ILSE as a centerpiece and in coordination with the program to demonstrate ignition and gain by Defense Programs. The FY 1995 budget does not support project construction of an accelerator for ILSE, but does support continued research and preparations for more intensive development on heavy ion fusion drivers. International cooperation on inertial fusion energy will be sought, where allowed within classification guidelines and in particular in driver development.

In FY 1995, Inertial Fusion Energy activities will also examine target designs for energy applications. This work will be in collaboration with the Inertial Confinement Fusion program. If allowed by classification guidelines, cooperation on target designs for energy can also be initiated with European and Japanese researchers. Many inertial fusion reactor concepts have been analyzed including ones completed in FY 1992 under this new IFE program. International comparison of these reactor concepts are planned to be part of the IFE activities in FY 1995.

II. A. Summary Table: Inertial Fusion Energy

Program Activity	FY 1993 Enacted	FY 1994 Enacted	FY 1995 Request	% Change
Heavy Ion Beams	$ 8,150	$ 1,200	$ 5,350	+346
Reactors and Materials	0	0	100	>999
Driver Concept Development	0	2,084	250	- 88
Targets for IFE	0	693	300	- 57
Total, Inertial Fusion Energy	$ 8,150	$ 3,977	$ 6,000	+ 51

II. B. Major Laboratory and Facility Funding

LAWRENCE BERKELEY LAB	$ 5,292	$ 2,550	$ 4,050	+ 59
LAWRENCE LIVERMORE NATIONAL LAB	$ 1,200	$ 837	$ 1,100	+ 31

III. Activity Descriptions: (New BA in thousands of dollars)

Program Activity	FY 1993	FY 1994	FY 1995
Inertial Fusion Energy			
Heavy Ion Beams	Evaluate test results of electrical pulse conditioning network and prototype accelerator cell. Conduct test of 2 MeV beam injection. Research and development will be performed for the Induction Linac Systems Experiments (ILSE).	A decision was made not to proceed with construction of the ILSE accelerator in FY 1994. Efforts directed toward technology improvements and testing of accelerator modules and pulsed power systems. Develop a full-scale alkali ion beam source and injector.	Prepare for a heavy ion beam physics test facility. Efforts will be directed toward technology improvements and testing of accelerator modules and pulsed power systems. Magnetic quadrupole transport of a full-scale alkali ion beam will be studied at low energy.
	$ 8,150	$ 1,200	$ 5,350
Reactors and Materials	$ 0	$ 0	$ 100

III. Inertial Fusion Energy (Cont'd):

Program Activity	FY 1993	FY 1994	FY 1995
Driver Concept Development	No activity.	For heavy ions, the induction linac concept would be improved through use of new materials, advanced ion beam stability control, and high precision focusing. Initiate improved codes with new high performance computers to predict detailed ion-beam performance, in particular, with advance in simulation of magnetic bending and focusing expected.	For heavy ions, the induction linac concept would be improved through use of new materials, advanced ion beam stability control, and high precision focusing. High performance computers and improved codes will predict detailed ion-beam performance.
	$ 0	$ 2,084	$ 250
Targets for IFE	No activity.	Conceive and study inertial fusion targets tailored for energy application in collaboration with ongoing U.S. studies of inertial fusion for defense applications. If allowed within classification guidelines, energy specific heavy-ion targets can be studied in cooperation with European researchers and experiments with laser-driven targets may be undertaken with Japanese researchers. International comparisons of existing reactor concepts may be a part of this activity.	If allowed within classification guidelines, energy specific heavy-ion targets can be studied in cooperation with European researchers and experiments with laser-driven targets may be undertaken with Japanese researchers. International comparisons of existing reactor concepts may be a part of this activity.
	$ 0	$ 693	$ 300
Inertial Fusion Energy	$ 8,150	$ 3,977	$ 6,000

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FY 1995 CONGRESSIONAL BUDGET REQUEST
ENERGY SUPPLY, RESEARCH AND DEVELOPMENT
(dollars in thousands)

KEY ACTIVITY SUMMARY

FUSION ENERGY

I. Preface: Program Direction

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 program is developing the magnetic and inertial approaches to attaining fusion energy as two separate and distinct programs, coordinating, in the latter case, with the Office of Defense Programs. International collaboration and increasing industrial involvement are essential elements of the program strategy and require extensive coordination efforts.

II. A. Summary Table: Program Direction

Program Activity	FY 1993 Enacted	FY 1994 Enacted	FY 1995 Request	% Change
Salaries and Expenses..........................	$ 6,493	$ 7,735	$ 8,500	+ 10
Other..	2,307	1,465	1,100	- 25
Total, Program Direction	$ 8,800	$ 9,200	$ 9,600	+ 4

III. Activity Descriptions: (New BA in thousands of dollars)

Program Activity	FY 1993	FY 1994	FY 1995
Program Direction			
Salaries and Expenses	Provided funds for salaries, benefits, and travel for 82 full-time equivalents (FTEs) in the Office of Fusion Energy and related program and management support staff in the Headquarters and field.	Provide funds for salaries, benefits, and travel for 83 FTEs, an increase of two over the FY 1993 budget.	Provide funds for salaries, benefits, and travel for 82 FTEs, a reduction of one FTE from the revised FY 1994 level. Provide for one additional FTE over the FY 1994 budget level and pay increases resulting, for example, from locality pay and normal within-grade increases.
	Funded staff for the Office of Fusion Energy activities including policy development; preparation of technical research and development plans; assessment of scientific needs and priorities; development and defense of budgets; review, evaluation, and funding of research proposals; monitoring, evaluation, and direction of laboratory work and allocation of resources; oversight of university and industrial research programs; and oversight of construction, ES&H, and operation of scientific R&D facilities. Managed programs to improve the tokamak concept and ensure development of inertial fusion energy. Continued ES&H oversight of preparation for and initiation of D-T experiments in TFTR. Continued physics experiments in support of the ITER and establishment of ES&H criteria for ITER. Managed the conceptual design phase of TPX. Managed other ongoing program activities consistent with the program's mission, Departmental priorities, improved contractor oversight, and ES&H regulations. Continued international collaborations relating to ITER and other major program projects. Considered ITER site selection options and prepared recommended Department position regarding site selection.	Continue program management as in FY 1993. Support ITER materials development, two new testing facilities, and international collaboration as ITER design activities intensify. Continue TPX project coordination and strong industry involvement. Support TFTR D-T. Improve the tokamak concept and ensure continuing development of inertial fusion energy. Continue physics experiments and establishment of ES&H criteria for ITER. Support and manage other ongoing program activities consistent with program missions, the Energy Policy Act of 1992, Departmental priorities, and improved contractor oversight. Join with foreign partners in planning for a comprehensive program to develop fusion energy, particularly including materials development facilities and related R&D.	Continue program management activities as in FY 1994 with particular emphasis on the ITER and TPX projects and the research and development activities that support the program's missions. Support development of the various technologies necessary for future tokamak reactors and power plants and the development of advanced materials. Manage basic physics research activities and identify promising advanced concepts. Manage design and R&D tasks for the ITER, including ES&H. Support TPX construction and related R&D activities. Manage other ongoing program activities including the DIIID and Alcator C-Mod facilities consistent with program missions, the Energy Policy Act of 1992, Departmental priorities, and improved contractor oversight, including continued development of reactor technologies for ongoing and planned facilities. Continue international collaboration on ITER particularly regarding research and development tasks, design issues, construction decisions, and site selection. Intensify activities relating to a U.S. commitment concerning construction of ITER and the related site selection activities. Continue extencive planning for the U.S. program and with foreign partners for a comprehensive program to develop fusion energy, particularly including

Program Activity	FY 1993	FY 1994	FY 1995
Salaries and Expenses (Cont'd)			materials development facilities and related R&D.
	Provided program and management support in the areas of budget and finance, personnel administration, acquisition and assistance, policy review and coordination, information resources management, and construction management support.	Continue to provide program and management support as in FY 1993, with an increase of two FTEs over the FY 1993 budget to reflect internal redistribution of Energy Research resources.	Continue to provide program and management support as in FY 1994, with a reduction of one FTE from the revised FY 1994 level and a net increase of one FTE over the FY 1994 budget.
	Supported magnetic fusion energy activities carried out by the Chicago Operations Office, primarily at the Princeton Area Office. PAO is responsible for the operation of DOE's largest fusion laboratory, the Princeton Plasma Physics Laboratory, which operates the Tokamak Fusion Test Reactor facility. Strengthened ES&H and contract management oversight at the site.	Continue to support magnetic fusion energy activities carried out by the Chicago Operations Office, primarily at the Princeton Area Office. Provide increased support for the expanded TPX activities.	Continue to support magnetic fusion energy activities carried out by the Chicago Operations Office at the FY 1994 level.
	Supported magnetic fusion energy activities at the San Francisco Operations Office.	Continue to support magnetic fusion energy activities at the San Francisco Operations Office.	Continue to support magnetic fusion energy activities at the San Francisco Operations Office.
	$ 6,493	$ 7,735	$ 8,500
Other	Provided funds for a variety of program support services such as printing, editing, and contractual support, for example, for timesharing on various information systems and communications networks and ES&H support. Provided support for employees at Chicago and San Francisco Operations Offices.	Continue at a reduced level the variety of program support required in FY 1993.	Continue at a reduced level the variety of program support required in FY 1994.
	$ 2,307	$ 1,465	$ 1,100

III. Program Direction (Cont'd):

Program Activity	FY 1993	FY 1994	FY 1995
Program Direction	$ 8,800	$ 9,200	$ 9,600

KEY ACTIVITY SUMMARY

FUSION ENERGY

I. Preface: Capital Equipment

The capital equipment revised request for FY 1995 of $10,299,000 supports the procurement of essential hardware for the experimental program. This permits the effective utilization of devices and people. Much of this equipment is used to support the operation of the fusion experimental devices or to make measurements and gather technical data. Some of this equipment replaces existing obsolete equipment while the remainder is new equipment. The principal equipment upgrade is for the DIII-D tokamak where the first phase of a longer term effort will be continued. When completed, DIII-D will be able to test prototype divertors for ITER and study current drive techniques relevant to ITER. Listed below is a summary of the specific capital equipment needs by sub-program.

II. A. Summary Table: Capital Equipment

Program Activity	FY 1993 Enacted	FY 1994 Enacted	FY 1995 Request	% Change
Confinement Systems	$ 6,717	$ 11,000	$ 5,200	- 53
Applied Plasma Physics	446	395	325	- 18
Development and Technology	6,087	4,200	4,074	- 3
Inertial Fusion Energy	850	400	700	+ 75
Total, Capital Equipment	$ 14,100	$ 15,995	$ 10,299	- 36

II. B. Major Laboratory and Facility Funding

LAWRENCE LIVERMORE NATIONAL LAB	$ 1,816	$ 570	$ 830	+ 46
OAK RIDGE NATIONAL LAB	$ 2,537	$ 1,567	$ 835	- 47
PRINCETON PLASMA PHYSICS LAB	$ 1,386	$ 125	$ 400	+220

III. Activity Descriptions: (New BA in thousands of dollars)

Program Activity	FY 1993	FY 1994	FY 1995
Capital Equipment			
Confinement Systems	Support is being provided for experimental operations of existing devices. Maintenance and modest upgrades to data acquisition systems is continuing by replacing/upgrading diagnostics hardware, analog to digital convertors, mass storage systems, etc., as needed for C-MOD, DIII-D, PBX, and TFTR.	Provide support for experimental operations of existing devices. Continue maintenance and modest upgrades to data acquisition systems by replacing/upgrading diagnostics hardware, analog to digital convertors, mass storage systems, etc., as needed for C-Mod, DIII-D, and TFTR.	Provide support for experimental operations of existing devices. Continue maintenance and modest upgrades to data acquisition systems by replacing/upgrading diagnostics hardware, analog to digital convertors, mass storage systems, etc., as needed for C-Mod and DIII-D.
	The TFTR pellet injector is being modified to make it compatible with tritium.	These funds will be used to upgrade the Fast Wave Current Drive system and to initiate the Radiative Divertor Equipment project, as a part of improvements to the DIII-D facility.	A decision has been made to defer further work on the upgrade to the Fast Wave Current Drive system and to slow the pace of the Radiative Divertor hardware upgrade. Prototyping work on a long pulse 110 GHz ECH system will be initiated to upgrade the capabilities of the D-III-D facility.
	The heating and current drive systems on PBX-M have been upgraded.		
	$ 6,717	$ 11,000	$ 5,200
Applied Plasma Physics	Provide general laboratory equipment for experimental research at national laboratories including computing equipment.	Provide general laboratory equipment for experimental research at national laboratories including computing equipment.	Reduce general laboratory equipment at national laboratories.
	$ 446	$ 395	$ 325
Development and Technology	Special and general purpose equipment is purchased to increase the efficiency and productivity of the research and development efforts and technology test facilities.	Special and general purpose equipment is purchased to increase the efficiency and productivity of the research and development efforts and technology test facilities.	Special and general purpose equipment is purchased to increase the efficiency and productivity of the research and development efforts and technology test facilities.
	$ 6,087	$ 4,200	$ 4,074

III. Capital Equipment (Cont'd):

Program Activity	FY 1993	FY 1994	FY 1995
Inertial Fusion Energy	Equipment funds are provided to support Heavy Ion Accelerator Physics Research.	Equipment funds are provided to support Heavy Ion Accelerator Physics Research.	Equipment funds are provided to support Heavy Ion Accelerator Physics Research.
	$ 850	$ 400	$ 700
Capital Equipment	$ 14,100	$ 15,995	$ 10,299

DEPARTMENT OF ENERGY
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ENERGY SUPPLY, RESEARCH AND DEVELOPMENT
(dollars in thousands)

KEY ACTIVITY SUMMARY

FUSION ENERGY

I. Preface: Construction

II. A. Summary Table: Construction

Program Activity	FY 1993 Enacted	FY 1994 Enacted	FY 1995 Request	% Change
General Plant Projects..........................	$ 2,000	$ 2,000	$ 2,000	0
Fire & Safety Protection Improvements...........	2,200	0	0	0
Tokamak Physics Experiment......................	0	0	45,000	>999
Total, Construction	$ 4,200	$ 2,000	$ 47,000	>999

III. Activity Descriptions: (New BA in thousands of dollars)

Program Activity	FY 1993	FY 1994	FY 1995
Construction			
General Plant Projects	Support projects to meet health, safety, and programmatic requirements and to provide miscellaneous modifications, additions, alterations, and non-major new construction items to meet programmatic goals.	Support projects at PPPL to meet health, safety, and programmatic requirements and to provide miscellaneous modifications, additions, alterations, and non-major new construction items to meet programmatic goals.	Support projects at PPPL to meet health, safety, and programmatic requirements and to provide miscellaneous modifications, additions, alterations, and non-major new construction items to meet programmatic goals.
	$ 2,000	$ 2,000	$ 2,000
Fire & Safety Protection Improvements	Provides for completion of a project to correct fire and safety deficiencies at the Princeton Plasma Physics Laboratory.	No activity.	No activity.
	$ 2,200	$ 0	$ 0
Tokamak Physics Experiment	No activity.	No activity.	For TPX, all Title I design activities will be completed and detailed design (Title II) will commence. Major long lead procurements for magnets and other hardware will be initiated.
	$ 0	$ 0	$ 45,000
Construction	$ 4,200	$ 2,000	$ 47,000

ENERGY SUPPLY RESEARCH AND DEVELOPMENT
(Tabular dollars in thousands. Narrative dollars in whole dollars.)

IV. A. Construction Funded Project Summary

Project No.	Project Title	Previous Obligations	FY 1993 Adjusted	FY 1994 Enacted	FY 1995 Request	Unappropriated Balance	TEC
GPE-900	General Plant Projects	$ XXX	$ 2,000	$ 2,000	$ 2,000	$ 0	$ 2,000
92-E-340	Fire & Safety Protection Improvement	2,600	2,200	0	0	0	4,800
94-E-200	Tokamak Physics Experiment (TPX)	0	0	0	45,000	552,000	597,000
Total, Fusion Energy		$ 2,600	$ 4,200	$ 2,000	$47,000	$552,000	$603,800

IV. B. Construction Funded Project Descriptive Summary

1. Project Title and Location: GPE-900 General Plant Projects Various locations

TEC: $ 2,000
TPC: $ 2,000

Start Date: 1st Qtr. FY 1995 Completion Date: 4th Qtr. FY 1996

2. Financial Schedule (Federal Funds):

Fiscal Year	Appropriated	Obligations	Costs
1995	$ 2,000	$ 2,000	$ 1,850

3. This project supports many small alterations, additions, modifications, replacements, and non-major new construction items required annually to provide continuity of operation, improvement in economy, road and structure improvements, elimination of health and safety hazards, minor changes in operating methods, and protection of the Government's significant investment in facilities. Currently the estimated distribution for FY 1994 by laboratory is as follows:

Princeton Plasma Physics Laboratory................................ $ 2,000

4. Total Project Funding (BA):

	Prior Years	FY 1993	FY 1994	FY 1995 Request
Construction	$ 0	$ 2,000	$ 2,000	$ 2,000

IV. B. Construction Funded Project Descriptive Summary

1. Project Title and Location: 94-E-200 Tokamak Physics Experiment
Princeton Plasma Physics Laboratory
Plainsboro, New Jersey

TEC: $597,000
TPC: $694,000

Start Date: 1st Qtr. FY 1994 Completion Date: 2nd Qtr. FY 2000

2. Financial Schedule (Federal Funds):

Fiscal Year	Appropriated	Obligations	Costs
1995	$ 45,000	$ 45,000	$ 43,500

3. Narrative:

(a) TPX has a dual mission of steady state and advanced tokamak operation. It is designed to develop and demonstrate optimized steady state operation modes that would provide the basis for a more attractive DEMO.

(b) The TPX project also supports the schedule and technical objectives of the International Thermonuclear Experimental Reactor program and enables the U.S. to remain an important major participant and contributor to the international fusion program.

(c) The design of TPX will be based on a reconfiguration of the Tokamak Fusion Test Reactor (TFTR) facilities into a steady state advanced tokamak using many of the existing TFTR facilities, following the TFTR shutdown and decommissioning.

(d) The funding request in 1995 is for Title I Design activities to be completed and detailed Title II design to start.

4. Total Project Funding (BA):

	Prior Years	FY 1993	FY 1994	FY 1995 Request
Construction	$ 0	$ 0	$ 0	$45,000
Capital Equipment	0	40	0	0
Operating Expenses	1,000	12,498	19,260	21,900

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ENERGY SUPPLY RESEARCH AND DEVELOPMENT
(Tabular dollars in thousands. Narrative material in whole dollars.)

Fusion Energy

1. Title and Location of Project: General Plant Projects

2a. Project No. GPE-900
2b. Construction Funded

3a. Date A-E Work Initiated, (Title I Design Start Scheduled): 1st Qtr. FY 1995

3b. A-E Work (Title I & II) Duration: Months vary per project

5. Previous Cost Estimate: None

4a. Date Physical Construction Starts: 3rd Qtr. FY 1995

4b. Date Construction Ends: 4th Qtr. FY 1996

6. Current Cost Estimate:
TEC -- $ 2,000
TPC -- $ 2,000

7. Financial Schedule (Federal Funds):

		Costs			
Fiscal Year	Obligations	FY 1993	FY 1994	FY 1995	After FY 1995
Prior Year Projects	XXXXXXXXX	$ 2,507	$ 0	$ 0	$ 0
1993 Projects	2,000	1,850	150	0	0
1994 Projects	2,000	0	1,850	150	0
1995 Projects	2,000	0	0	1,850	150

8. Brief Physical Description of Project

These projects provide for the many miscellaneous alterations, additions, modifications, replacements, and non-major new construction items required annually to provide continuity of operation, improvement in economy, road and street improvements, elimination of health and safety hazards, minor changes in operating methods, and protection

1. Title and Location of Project: General Plant Projects	2a. Project No. GPE-900 2b. Construction Funded

8. Brief Physical Description of Project (Continued)

of the Government's significant investment in facilities at the present time. The continuing review of our requirements will result in some of the projects being changed in scope; it will also result in other projects being added to the list with the necessary postponements of some now listed, all depending on conditions or situations not apparent at this time.

The current estimated distribution of FY 1995 funds by location is as follows:

Princeton Plasma Physics Laboratory.. $ 2,000

9. Purpose, Justification of Need for, and Scope of Project

The following are tentative examples of the major items to be performed at PPPL:

Princeton Plasma Physics Laboratory*... $ 2,000

Miscellaneous Building and Facility Betterments and Modifications........... $ 410
Electric Power Modifications... $1,100
Office Space - Material Control.. $ 300
D Site Cooling System Modifications.. $ 190

These funds cover the Fusion Energy program's specific modifications for modernization and safety improvements to existing facilities.

* These projects will be constructed at the Princeton Plasma Physics Laboratory which is non-Government owned property.

1. Title and Location of Project: General Plant Projects

2a. Project No. GPE-900
2b. Construction Funded

10. Details of Cost Estimate

Not available at this time.

11. Method of Performance

Design and engineering will be on the basis of negotiated subcontracts and construction work under fixed price subcontracts awarded on the basis of competitive bidding.

12. Funding Schedule of Project Funding and Other Related Funding Requirements

This item does not apply to general plant projects.

Since needs and priorities may change, other projects may be substituted for those listed, and some of these may be located on non-Government owned property.

13. Narrative Explanation of Total Project Funding and Other Related Funding Requirements

This item does not apply to general plant projects.

DEPARTMENT OF ENERGY
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ENERGY SUPPLY RESEARCH AND DEVELOPMENT
(Tabular dollars in thousands. Narrative material in whole dollars.)

Fusion Energy

1. Title and Location of Project: Tokamak Physics Experiment (TPX)
Princeton Plasma Physics Laboratory (PPPL)
Plainsboro, New Jersey*

2a. Project No. 94-E-200
2b. Construction Funded

3a. Date A-E Work Initiated, (Title I Design Start Scheduled): 1st Qtr. FY 1994

3b. A-E Work (Title I & II) Duration: 46 Months

5. Previous Cost Estimate: None
Total Estimated Cost (TEC) -- N/A
Total Project Cost (TPC) -- N/A

4a. Date Physical Construction Starts: 3rd Qtr. FY 1995

4b. Date Construction Ends: 4th Qtr. FY 2000

6. Current Cost Estimate:
TEC -- $597,000
TPC -- $694,000

7. Financial Schedule (Federal Funds):

Fiscal Year	Appropriation	Obligations	Costs
1993	0	0	0
1994	0	0	0
1995	45,000	45,000	43,500
1996	118,000	118,000	108,000
1997	132,000	132,000	128,000
1998	128,000	128,000	139,000
1999	114,000	114,000	110,000
2000	60,000	60,000	68,500

* This project will be located on non-Government owned land. The U.S. Government has leased this land from Princeton University for a 40-year period beginning in October, 1986.

1. Title and Location of Project:	Tokamak Physics Experiment (TPX) Princeton Plasma Physics Laboratory (PPPL) Plainsboro, New Jersey*	2a. Project No. 94-E-200 2b. Construction Funded

8. Brief Physical Description of Project

The design of TPX will be based on the reconfiguration of the Tokamak Fusion Test Reactor (TFTR) facilities into an advanced tokamak experimental facility to carry out research that extrapolates to steady-state. Many of the TFTR facilities, including buildings, power supplies, motor generators, vacuum pumping systems, computer control systems, instrumentation systems, a water cooling system, utilities, and diagnostics are reusable for TPX. In addition, existing cryogenic equipment at Lawrence Livermore National Laboratory (LLNL) will be relocated to PPPL for use on TPX.

Construction of the TPX facility will include the following new facilities: 1) a high-aspect ratio, advanced tokamak with support structure, vacuum vessel, cryostat, vacuum pumping system, superconducting magnet coils, support systems; and 2) an on-site helium refrigeration plant that utilizes the existing MFTF-B refrigerator.

9. Purpose, Justification of Need For, and Scope of Project

The purpose of the U.S. Magnetic Fusion program is to develop fusion as a safe, environmentally sound energy source and to prove fusion energy to be technically and economically credible. Two key science issues in developing an attractive fusion demonstration power plant (DEMO) are extending the tokamak concept to the steady-state regime and pursuing advances in tokamak physics. TPX will address both issues and play a unique role in the world fusion program by developing stable plasma conditions with improved reactor characteristics (e.g., higher pressures, better confinement, lower input energy requirements). The aim would be to maintain these conditions for a sufficiently long period to demonstrate their utility in a power reactor. The central role of TPX then, is to point the way to a more efficient and economically attractive DEMO rather than relying on conservative extrapolation to a DEMO sized device from the present scientific data base.

The TPX project also complements the technical objectives of the International Thermonuclear Experimental Reactor (ITER) program and enables the U.S. to remain an important major participant and contributor to the international fusion program. Both the Secretary of Energy Advisory Board Task Force on Energy Research Priorities and the Fusion Energy Advisory Committee, as well as the heads of the major foreign fusion programs, have endorsed the unique role of the TPX mission in the world fusion effort. Failure to proceed with the TPX Project would seriously impede development of an attractive DEMO, and also impair the future ability of the U.S. fusion program to retain an adequate level of scientific expertise until such time that ITER is constructed and operated.

1. Title and Location of Project:	Tokamak Physics Experiment (TPX) Princeton Plasma Physics Laboratory (PPPL) Plainsboro, New Jersey*	2a. Project No. 94-E-200 2b. Construction Funded

9. Purpose, Justification of Need For, and Scope of Project (Continued)

The TPX would move tokamak and fusion development into a new era. For the first time, it would incorporate the main features of presently envisioned tokamak reactors, except for the use of tritium fuel. It would seek to significantly improve the physics of tokamaks in long pulse operation by exploring advanced regimes with the potential for better confinement, higher pressure limits, and a high fraction of internally-driven steady-state current, leading to an attractive DEMO concept. It would also advance reactor technologies including superconducting magnets, heat resistant internal components, steady-state plasma heating and current drive systems, and remote maintenance. In summary, the TPX would be an important and exciting experiment to advance fusion energy development in the U.S. and in the world.

The funding request of $45,000,000 in FY 1995 is for continuation of the preliminary design started in FY 1994 (in accordance with Congressional direction contained in the Energy and Water Development Conference Report 103-305 dated October 22, 1993) and start of final design. Additionally, major procurement subcontracts for the conductor to be used in the superconducting magnets and long-lead materials will be awarded during this fiscal year.

1. Title and Location of Project:	Tokamak Physics Experiment (TPX) Princeton Plasma Physics Laboratory (PPPL) Plainsboro, New Jersey*	2a. Project No. 94-E-200 2b. Construction Funded

10. Details of Cost Estimate a/b/

	Item Cost	Total Cost
(a) EDIA and Construction Management Costs		$162,600
(1) Engineering Design, Inspection and Administration (EDIA) at 46% c/ of construction costs b/	$148,400	
(2) Construction Management at 5% of construction costs b/	14,200	
(b) Construction costs		325,400
(1) Improvements to land and utilities	110	
(2) Buildings and building modifications	3,190	
(3) Special features		
(a) Tokamak systems	190,800	
(b) Other systems	131,300	
Subtotal		$ 488,000
(f) Contingencies at approximately 23% of the above costs		$ 109,000
Total line costs (Section 12.a.i)		$ 597,000

11. Method of Performance

A fusion program objective is for TPX to be a National project with broad U.S. fusion program involvement in order to make full use of the technical and scientific capabilities that exist throughout the U.S. program. Consequently, the design and engineering for TPX will be an effort involving the participation of several national laboratories, other DOE research centers, and private industry. All program participants will benefit from the TPX technical and scientific challenges and progress. Industrial subcontracts for the design and fabrication for special facilities will be accomplished by cost-type contracts for the design and research and development phases and by negotiated cost-type or fixed price contracts for the fabrication phase. Negotiated cost-type industrial subcontracts will be awarded for Systems Integration Support and Tokamak Construction Management.

a/ These estimates are based on the Conceptual Design Review completed in March, 1993; conceptual design is 100% complete.

b/ All costs have been escalated to the mid-point of construction (FY 1998) using the DOE-ER escalation rates published for DOE Construction Projects in February, 1993.

c/ EDIA as a percentage of construction cost (over $150 million) is much lower (29%) if the replacement construction cost of reuseable PPPL/LLNL facilities and equipment is taken into account.

1. Title and Location of Project:	Tokamak Physics Experiment (TPX) Princeton Plasma Physics Laboratory (PPPL) Plainsboro, New Jersey*	2a. Project No. 94-E-200 2b. Construction Funded

12. Funding Schedule of Project Funding and Other Related Funding Requirements

(1) Total project funding	FY 1993	FY 1994	FY 1995	FY 1996	FY 1997	FY 1998	FY 1999	FY 2000	TOTAL
(a) Total facility costs									
(i) Line item (Section 10)...	0	$ 0	$ 43,500	$108,000	$128,000	$139,000	$110,000	$ 68,500	$597,000
Total facility costs	0	$ 0	$ 43,500	$108,000	$128,000	$139,000	$110,000	$ 68,500	$597,000
(b) Other project costs									
(i) R&D necessary for construction.............$	200	$ 5,000*	$ 20,000	$ 15,700	$ 3,000	500	0	0	$ 44,400
(ii) Concept design costs.....$	10,100	0	0	0	0	0	0	0	$ 10,100
(iii) Decontamination & decommissioning (D&D)....									$ 0
(iv) NEPA Documentation Costs....................$	300	0	0	0	0	0	0	0	$ 300
(v) Other project related costs (project physics & prep for ops)..........$	2,200	$ 1,900*	$ 2,000	$ 1,600	$ 2,700	$ 4,500	$ 9,300	$ 5,700	$ 29,900
(vi) Non-Federal contribution.									$ 0
(vii) Preliminary design.......$	0	$ 12,300*	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 12,300
Total other project costs......$	12,800	$ 19,300	$ 21,900	$ 17,300	$ 5,700	$ 5,000	$ 9,300	$ 5,700	$ 97,000
Total project costs............$	12,800	$ 19,300*	$ 65,400	$125,300	$133,700	$144,000	$119,300	$ 74,200	$694,000

(2) Other related annual costs (FY 2000 dollars. Estimated life of facility: 10 years)

(a) Facility operating costs..	$ 95,000
(b) Programmatic operating expenses directly related to the facility..........	$ 45,000
(c) Capital equipment not related to construction but related to the programmatic effort to the facility..	$ 10,000
Total related annual costs..	$150,000

* Consistent with Congressional intent for TPX project design to begin in FY 1994 using operating expense funds (See Conference Report 103-305 dated October 22, 1993).

1. Title and Location of Project: Tokamak Physics Experiment (TPX)
Princeton Plasma Physics Laboratory (PPPL)
Plainsboro, New Jersey*

2a. Project No. 94-E-200
2b. Construction Funded

13. Narrative Explanation of Total Project Funding and Other Related Funding Requirements

a. Total project funding

1. Total Facility Costs - Description is provided in Sections 8 and 9.
   (a) Line item -- Description is provided in Sections 8 and 9.
   (b) PE&D -- Included in the Line Item (Section 10).
   (c) Expense-funded equipment -- None.
   (d) Inventories -- None.
   (e) Non-Federal contribution -- None.

2. Other Project costs
   (a) R&D necessary to Complete Construction -- Technology development, prototyping, and mockup, fabrication and testing to support the design and cost-effective fabrication of the magnets, vacuum vessel, divertor and first wall, remote maintenance, shielding, and instrumentation and control systems.
   (b) Conceptual Design -- Includes establishing the mission, objectives, and requirements for the project and developing the scope and cost of the project to meet these requirements. The project scope is defined in summary level engineering drawings and specifications in sufficient detail to enable preparation of a total project cost estimate and schedule.
   (c) Decontamination and Decommissioning (D&D) -- Not applicable to this Construction Project. Costs to D&D the TFTR device and test cell is covered as a separate project.
   (d) NEPA documentation costs are to prepare an Environmental Assessment for construction and operation of TPX. Other documentation such as the PSAR and FSAR is included in the Line Item (a)(1)(a) above.
   (e) Other project related costs include physics design support and preparation for operations staffing build-up and training.
   (f) Non-Federal contributions -- None positively identified to date. Preliminary discussions with State of New Jersey have been held.
   (g) Preliminary Design - Engineering design activities funded by operating funds approved in FY 1994 Energy & Water Development Appropriations Conference Report 103-305 dated October 22, 1993.

13. Narrative Explanation of Total Project Funding and Other Related Funding Requirements (Continued)

b. Related annual funding

(a) Facility operating costs -- This facility is estimated to operate for a period of 10 years. The major elements comprising the annual operating costs will be personnel salaries, materials and services, maintenance, spare parts, and utilities.

(b) Programmatic operating expenses directly related to the facility -- Primarily includes the salaries and expenses of the staff personnel (physicists, engineers, and technicians) to carry out the experimental program.

(c) Capital equipment not related to construction but to programmatic efforts -- Estimated annual capital equipment expenses to support the experimental programmatic goals.