DEPARTMENT OF ENERGY
FY 1994 CONGRESSIONAL BUDGET REQUEST
ENERGY SUPPLY, RESEARCH AND DEVELOPMENT

OVERVIEW

FUSION ENERGY

Fusion offers the promise of a safe, environmentally attractive, 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 Congress and the Administration have recognized the potential of fusion. The Energy Policy Act of 1992 directs the Secretary of Energy to conduct a fusion energy program that "...by the year 2010 will result in a technology demonstration which verifies the practicability of commercial electric power production...." 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..." and includes fusion research in the investment package. Widespread uncertainty about the availability of safe and secure energy options and about public acceptance of major technologies capable of generating 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. A review of the Nation's fusion program by the Department has led to a redefinition of the program's goals. As part of this review, the Fusion Policy Advisory Committee (FPAC) concluded that there are compelling reasons for the U.S. to initiate a goal-oriented fusion energy program and that the present fusion program is technically ready to proceed with its next major steps. The goals for the fusion energy program are based on the FPAC recommendations and take into account realistic budget constraints.

The Department's planning looks to fusion energy as an important option to be pursued as a source of electricity-generating capacity. A key goal of the program is to prove fusion energy to be a technically and economically credible energy source with an operating demonstration plant by about the year 2025 and an operating commercial plant by about the year 2040. The final step toward commercialization would be construction of a demonstration power plant. The overall program aimed at achieving these goals must include the study and development of the most effective confinement systems, materials, and technology to ensure the eventual economic success of fusion. 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 (TFTR) in the U.S. and the Joint European Torus in the European Community are very 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. There have been numerous physics and technology accomplishments in the Magnetic Fusion Energy program, including:

(1) improvement in tokamak performance, in terms of fusion power production, of more than a factor of a million over the past 20 years;

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

(3) encouraging tests showing promise of steady-state operation by using advanced power sources; experimental confirmation that the plasma can self-heat thereby reducing the amount of power needed to drive the system;

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

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

(6) development of improved fueling, and impurity control techniques that 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 technology 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, and is part of the President's Economic Investment package.

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 tritium will significantly increase the amount of energy obtained from the fusion reactions over previous experiments using only deuterium, and verify the extrapolations that have been made from non-tritium fusion experiments. The plan is to extend, substantially, the preliminary tritium results obtained in the Joint European Torus in England during 1991. The power produced during the fusion reactions in TFTR will be equal to about one half of the power put into the device to make the reactions occur representing the most advanced conditions ever attained. The goal is to produce about 10 million watts of fusion power for about one second. This will make TFTR the first tokamak to perform extensive D-T experiments to provide important data on plasma self-heating for future development steps such as ITER. The second major program element is ITER. The U.S. has participated with the European Community, Japan, and the Soviet Union (now the Russian Federation) on 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 1,000 MW of fusion power, under ignition conditions, and serve as the test bed for fusion technology in support of a Demonstration Power Reactor (DEMO). The third element is TPX, a 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 is intended to replace TFTR and 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 strong base program. The base program provides the fundamental physics and technology research required to support ITER, TPX, and a demonstration reactor.

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 planned for ITER. It would benefit from 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 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 specific to the Induction Linac Systems Experiment (ILSE) will be postponed as a result of a recent decision not to proceed in FY 1994 with the construction of the accelerator for ISLE. The revised 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 for $347,595,000. This includes funding to carry out the D-T experiments in TFTR and to fully support the ITER Engineering Design Activities requirements. Funding for Title I design of TPX is provided to develop tokamak improvements to increase the attractiveness of a post-ITER fusion reactor. Improved hardware will be provided for the DIII-D to provide the necessary 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 support both ITER and tokamak improvement efforts. In those ITER task areas in which the U.S. does not have the lead responsibility, the base technology program will support the transfer of high leverage technology to industry as well as provide support for other existing projects.

The highest priority in the magnetic fusion energy program is the introduction of deuterium and tritium fuel in the TFTR facility and carrying out the planned experiments. Another high priority is full participation in the ITER engineering design phase, including conducting R&D in the United States to support the design of ITER. In particular, experiments on D-III-D and Alcator C-Mod, are addressing key ITER design issues and, therefore, are receiving funding priority. In order to improve the post-ITER tokamak reactor concept, priority is also being given to the design of the TPX, a steady-state advanced tokamak. This project specifically included in the FY 1993 Conference Report, also is contained in the President's investment package "A Vision for Change in America." The Princeton Beta Experiment at Princeton and the Advanced Toroidal Facility at Oak Ridge were built to investigate improved tokamak physics but they are given a lower priority at this time and neither will be operating in FY 1994. The base program, which supports ITER, TPX and the development of materials and nuclear components required for a demonstration power plant, will continue below the FY 1993 funding level because of the higher priorities identified above.

This budget includes a reduction to university overhead consistent with the Administration's economic plan to shift national spending from overhead to research.

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(Tabular dollars in thousands. Narrative in whole dollars.)

LEAD TABLE

FUSION ENERGY

Activity	FY 1992 Adjusted		FY 1993 Appropriation		FY 1993 Adjustment		FY 1994 Request
Operating Expenses							
Confinement Systems	$180,279		$182,780		-$18,568		$157,400
Applied Plasma Physics	61,750		62,450		-590		59,805
Development & Technology	56,650		67,550		-1,150		81,300
Planning & Projects	337	a/	4,800		0		4,895
Inertial Fusion Energy	8,150		8,150		-1,300		4,000
Program Direction	7,500		8,800		0		9,200
Subtotal Operating Expenses	314,666		334,530		-21,608		316,600
Capital Equipment	13,000		20,980		-6,880		15,995
Construction	4,550		4,200		0		15,000
Subtotal	$332,216	b/	$359,710		-$28,488	d/	$347,595
Adjustment	0		-20,000	c/	20,000	c/	0
Total	$332,216		$339,710		-$8,488	e/	$347,595

a/ Excludes $3,913,000 which has been transferred to the SBIR program.
b/ Reflects transfer of HIFAR from the Basic Energy Sciences program to the Fusion Energy program in FY 1992.
c/ Program specific general reduction.
d/ Program specific general reduction of $20,000,000 and general reduction for use of prior year balances of $8,488,000.
e/ General reduction for use of prior year balances.

	FY 1992 Adjusted	FY 1993 Appropriation	FY 1993 Adjustment	FY 1994 Request
Operating Expenses	$314,666	$321,410	-$8,488	$316,600
Capital Equipment	13,000	14,100	0	15,995
Construction	4,550	4,200	0	15,000
Total Program	332,216	339,710	-8,488	347,595
Staffing (FTEs)				
Headquarters	64	60	0	60
Field Office	14	20	0	21
Total	78	80	0	81

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

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

SUMMARY OF CHANGES

Fusion Energy

FY 1993 Appropriation	$ 359,710
- Adjustment - Program specific general reduction	- 20,000
- Adjustment - General reduction for use of prior year balances	- 8,488
FY 1993 Adjusted	$ 331,222

Operating Expenses

Confinement Systems Supports continued operation of DIII-D and Alcator C-Mod. Repair of ATF continues in preparation for operation in FY 1995. Princeton Beta Experiment-M operation will be shutdown during FY 1994. The schedule for D-T experiments in TFTR is maintained. R&D in support of the Tokamak Physics Experiment (TPX) design effort is provided.	- 6,812
Applied Plasma Physics Theory, diagnostic development, small university experiments and operation of the National Energy Research Supercomputer Center are funded slightly below the FY 1993 level with the primary focus on supporting ITER and TPX.	- 2,055
Development and Technology This increase primarily 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 effort.	+ 14,900
Planning and Projects Provides primarily for SBIR obligations.	+ 95

Inertial Fusion Energy..	- 2,850
Activities are redirected as a consequence of the decision to defer consideration of construction of the accelerator for Induction Linac System Experiments (ILSE).	
Capital Equipment..	+ 1,895
A slight increase in capital equipment funds is primarily associated with support for equipment improvement at D-III-D.	
Construction..	+ 10,800
The increase is associated with the initiation of A-E design on the Tokamak Physics Experiment (TPX).	
Program Direction..	+ 400
Funds are provided for 1 additional FTE's in support of ITER.	
FY 1994 Congressional Budget Request..	$ 347,595

DEPARTMENT OF ENERGY
FY 1994 CONGRESSIONAL BUDGET REQUEST
ENERGY SUPPLY, RESEARCH AND DEVELOPMENT
(dollars in thousands)

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 by preparing for 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. 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 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, such as ITER, is being carried out in close cooperation with experimental and theory groups supported by the Applied Plasma Physics subprogram.

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.

Research in handling the power exhausted from the plasma and in impurity control, fueling and ash removal is critical for the operation of next generation devices, such as ITER. This is the most difficult design issue for ITER. In a fusion device, impurities must be continuously controlled, because they can dilute the deuterium-tritium fuel, cool the plasma, and/or cause the plasma to contract and become unstable. A major source of these impurities is from surfaces in contact with the plasma. Studies are being conducted to ensure that the plasma is kept as clean as possible by treating surfaces or selecting materials to reduce the generation of impurities and by isolating the impurities that are generated. Another particle control issue concerns methods of replacing the fuel in the plasma that is consumed by the fusion reactions or that escape from the plasma. Current experiments are studying fueling the plasma by injection of high-velocity frozen hydrogen or deuterium pellets.

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. 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 continuous 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 current drive in its technology phase.

The behavior of alpha particles, the helium nuclei that are produced in fusion reactions, as a part of the confined plasma, is the major 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 energy potential of magnetic fusion. Work on this issue will begin to be 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 less expensive 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 and demonstrate optimized steady-state operating modes. Steady-state operation in TPX will also provide valuable information for the nuclear testing phase of ITER. The FY 1994 request includes $20 million for TPX as part of the President's 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 performing burning plasma physics experiments on ITER. The study of D-T plasmas and alpha particle physics will be emphasized in the TFTR. 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). The Alcator C-MOD facility at the Massachusetts Institute of Technology (MIT), will study radio-frequency heating, energy confinement, and particle control in a high-field, high-density plasma. At the Lawrence Livermore National Laboratory (LLNL), the Microwave Tokamak Experiment (MTX) aimed at tokamak heating with a free electron laser was completed in 1992. This represents the completion of a collaborative program with the Japanese and no subsequent operations are planned; however, LLNL scientists and engineers will collaborate on the DIII-D program.

Research on existing advanced toroidal devices will be supported at a modest level. The Princeton Beta Experiment (PBX-M) at PPPL, with its improved capabilities to control the plasma current and pressure profiles to study energy confinement and the second regime of stability, carried out limited operations in FY 1992 and FY 1993. In FY 1994, PBX-M will be shut down to focus resources on the completion of TFTR D-T experiments. The Advanced Toroidal Facility (ATF), an alternate toroidal configuration to a tokamak, at the Oak Ridge National Laboratory (ORNL) was shut down during FY 1992. This facility enables the study of a toroidal configuration that does not require a current in the plasma and is inherently capable of steady-state operation. The repairs and refurbishment of the facility, begun in FY 1993, will continue in FY 1994 to resume operation in mid-FY 1995.

In response to a reduced number of major operating experiments, on-site and off-site national collaboration on the remaining facilities is being encouraged to take advantage of the experience, skills, and resources of fusion teams at widely spread national laboratories and universities. Lawrence Livermore National Laboratory and Oak Ridge National Laboratory scientists and engineers will continue major collaborations on DIII-D at General Atomics. Although international collaboration on foreign tokamaks will be reduced, 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.

This budget includes $800,000 in FY 1993 and FY 1994 in direct support of FCCSET education activities.

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

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

Program Activity	FY 1992 Enacted	FY 1993 Enacted	FY 1994 Request	% Change
Tokamak Fusion Test Reactor (TFTR).............	$ 78,486	$ 73,215	$ 79,100	+ 8
Base Toroidal..................................	65,195	65,483	62,800	- 4
Advanced Toroidal..............................	11,526	13,729	8,500	- 38
Burning Plasma Experiment (BPX)................	25,072	0	0	0
Tokamak Physics Experiment (TPX)...............	0	11,785	7,000	- 41
Total, Magnetic Fusion Energy - Confinement Systems	$ 180,279	$ 164,212	$ 157,400	- 4

II. B. Major Laboratory and Facility Funding

LAWRENCE LIVERMORE NATIONAL LABORATORY	$ 7,380	$ 4,826	$ 4,500	- 7
OAK RIDGE NATIONAL LABORATORY	$ 9,534	$ 11,675	$ 12,190	+ 4
PRINCETON PLASMA PHYSICS LABORATORY	$ 103,780	$ 92,139	$ 86,960	- 6

III. Activity Descriptions: (Budget Obligations in thousands of dollars)

Program Activity	FY 1992	FY 1993	FY 1994
Magnetic Fusion Energy - Confinement Systems			
Tokamak Fusion Test Reactor (TFTR)	With the completion of the upgrade of ion cyclotron radio frequency (ICRF) wave heating system and the upgrade of limiter tiles in the vacuum chamber, the research program focused on determining the optimum scenarios for D-T operation. Improved performance was achieved, especially with the use of lithium pellets to condition the discharge. Preparation for D-T operation intensified, including the commissioning of the tritium handling systems and the installation and testing of new diagnostics to study alpha particles. Scientists from ORNL began collaboration on ICRF heating and pellet fueling experiments. The additional $3.4 million provided by the FY 1992 reprogramming request funded the increased overhead burden at PPPL resulting from the phaseout of BPX project activities and increased costs resulting from required safety and environmental improvements.	TFTR shut down November 1, 1992, to complete the modifications required for D-T operation. Major modifications include: 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 will occur in June, 1993. Following a thorough review of procedures and safety systems, D-T experiments are scheduled to begin in September, 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.
	$ 78,486	$ 73,215	$ 79,100

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

Program Activity	FY 1992	FY 1993	FY 1994
Base Toroidal	The energy confinement and stability program with control of plasma current and pressure profile was continued on DIII-D at higher electron cyclotron heating (ECH) and ICRF power levels. About 100,000 amps of plasma current was driven using ICRF wave power. Plasma profile control experiments were performed in support of the ITER program. Extensive studies of the physics of improved confinement conditions were carried out. Scientists from ORNL expanded their collaboration on the DIII-D program.	At DIII-D, the ICRF power will be increased to 6 MW. Experiments on fast wave current drive to test this technique for ITER will be initiated. Advanced divertor operation with a new cryo-pump will be evaluated as a first step in developing the radiative divertor concept. High stability limit experiments with good confinement will be continued by further improvements in current profile control. ORNL collaboration will be continued and the LLNL collaboration will be expanded.	At DIII-D, the 2 MW 110 GHz ECH system will be completed and design of an ITER-relevant radiative divertor will be initiated. Current drive experiments will continue with higher power ECH and ICRF heating techniques. ORNL and LLNL collaboration continues.
	Alcator C-MOD achieved first plasma operation in October, 1991. Following a shutdown to install additional hardware, operation was resumed in March, 1992. In April, 1992, a magnetic coil failure occurred. During the remainder of the year, the machine was disassembled and the failed coil was repaired.	After finishing the coil repair, Alcator C-MOD will complete the ohmic heating phase of operation and begin ICRF wave heating experiments at the 2 MW level.	ICRF heating experiments on Alcator C-MOD will be increased to the 4 MW level, up from 2 MW in FY 1993. Evaluation of confinement conditions in high density, high magnetic field regimes will be carried out. Vacuum vessel wall coating studies and plasma impurity movement investigations will be continued. Studies of plasma shapes of high elongation and the effects of high power heating on plasma stability will begin. Divertor studies in support of ITER will also begin.
	Single pulse microwave heating and confinement experiments in a high density plasma were conducted on MTX using a Free Electron Laser. The experimental results agreed well with the theoretical predictions of microwave power absorption. MTX was closed out in July 1992 following completion of a collaborative agreement with the Japanese.	No activity. Scientific staff redirected to support research on DIII-D.	No activity. Scientific staff redirected to support research on DIII-D.

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

Program Activity	FY 1992	FY 1993	FY 1994
Base Toroidal (Cont'd)	Collaborative experiments on plasma edge physics, particle control, fueling, heating, current drive, and confinement were continued on TEXTOR, ASDEX-U, JET, and TORE SUPRA, all in Europe.	Collaborative experiments on plasma edge physics, particle control, fueling, heating, current drive, and confinement will be continued on TEXTOR, ASDEX-U, and TORE SUPRA, all in support of ITER. Physics design analyses and physics R&D coordination in support of ITER will be continued. The third phase of the development of a "pumped limiter" system for particle control and the upgrade of the pellet injector technique for plasma fueling will be completed.	Collaborative experiments on plasma edge physics, particle control, fueling, heating, current drive, and confinement will be continued on modified TEXTOR, ASDEX-U, TORE SUPRA (with long pulses) in support of ITER; and 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.
	$ 65,195	$ 65,483	$ 62,800
Advanced Toroidal	The Advanced Toroidal Facility program was shutdown due to budget priorities. Some of the physics staff worked on experiments at DIII-D, TFTR and PBX-M.	ATF shutdown continues, but reassembly of ATF was initiated. Modest repairs to the helical magnet coil are in progress. Collaborative activities on DIII-D, TFTR, and PBX-M will continue with scientific personnel from ATF.	ATF reassembly will continue in preparation for operations in FY 1995. Collaborative activities on DIII-D and TFTR continue.
	The PBX-M experimental program has resumed development of two promising alternative plasma heating techniques called lower hybrid wave current drive for controlling the current in the plasma and Ion-Bernstein Wave (IBW) heating, a promising alternative heating technique; energy confinement studies and divertor operation will be conducted using the unique plasma shaping capability of PBX-M; also, fast electron transport is being studied.	PBX-M operation was suspended for about 6 months due to funding limitations at PPPL. Experimental operation later in the year will focus on techniques of current profile control and its uses as a tool to achieve second stability plasma confinement regime operation through different operating modes. Fluctuations and energy confinement studies will continue, IBW wave heating power will be upgraded to 4 MW.	PBX-M will be shut down in FY 1994.
	$ 11,526	$ 13,729	$ 8,500

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

Program Activity	FY 1992	FY 1993	FY 1994
Burning Plasma Experiment (BPX)	The Secretary of Energy Advisory Board Task Force on Energy Research Priorities recommended cancellation of BPX because of outyear budget constraints. During the first part of FY 1992, the project redirected its effort to develop less costly BPX-generic tokamak concepts as recommended by the Task Force. Following the approval of the fusion program reprogramming, the BPX project was closed out.	No activities.	No activities.
	$ 25,072	$ 0	$ 0
Tokamak Physics Experiment (TPX)	The Fusion program reprogramming for FY 1992 reallocated funds for pre-conceptual design of a new domestic initiative (Tokamak Physics Experiment) to develop improved tokamak operating regimes for a demonstration power reactor.	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 continue to support the design of the TPX to address the scientific issues associated with improving post-ITER reactor concepts. R&D will be conducted for technology development, prototyping, and mockup testing to support the design and cost-effective fabrication of the superconducting magnets, vacuum vessel, divertor and first wall, remote maintenance, shielding, and instrumentation and control systems. Provides $7 million of the $20 million as part of the President's Economic Investment package.
	$ 0	$ 11,785	$ 7,000
Magnetic Fusion Energy - Confinement Systems	$ 180,279	$ 164,212	$ 157,400

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 and to the achievement of program goals for ITER and the design of other reactor concepts. This subprogram has three elements: fusion plasma theory, experimental plasma research, and magnetic fusion energy 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 the control concepts, and basic data necessary to design and conduct the fusion energy program's reactor fusion experiments. Activities include: theoretical and experimental physics, analysis and design supporting major devices, and large-scale computing system 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 focussed on this issue. The resulting improved transport physics understanding 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. In FY 1994, in order to test the evolving theoretical capabilities, emphasis will be given to understanding transport to predict improved confinement conditions expected in tokamaks such as DIII-D. Thus, it may be possible to characterize external influences such as heating power and applied electric and magnetic fields that cause the transitions to improve confinement plasma operating conditions. An aim is to improve predictive capabilities for the design of TPX.

Theoretical activities will further support ITER analyses of containment and thermalization of fast alpha particles produced in fusion burning; control of large scale plasma instabilities; current drive; impurity control; and the detailed modelling of 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. Several university scale programs are carried out using small scale toroidal devices which exploit different magnetic configurations including tokamaks, stellarators and reverse field pinches. In FY 1994, at selected tokamaks, diagnostic equipment will be used to measure properties associated with energy and particle transport. The first applications of new diagnostics for measuring alpha particle distribution and associated physics effects will be supported at TFTR and JET. Diagnostic systems for ITER will be developed and tests to qualify diagnostic components for ITER will be initiated. The TEXT tokamak at University of Texas, Austin, will be operated with new electron cyclotron heating and diverters 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. New ideas currently receiving first tests are directed toward improved heating and current drive, better particle and energy control, and plasma stability at higher beta pressure ratios. A further, small-scale initiative that is not limited to toroidal magnetic concepts, will be started in FY 1993 to foster new concepts and ideas that could lead to more attractive reactor concepts. Most of the Experimental Plasma Research work is conducted at universities, with some at national laboratories and industrial centers as well.

The Energy Sciences computing network provides access to state-of-the-art computational hardware (CRAY computers) for the fusion energy program. The network and related computing facilities support the development of models and codes, plasma theory, management and interpretation of experimental results, and the design of large scale fusion experiments. The network infrastructure links the computers at LLNL and five user

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

service centers at LLNL, LANL, General Atomics, PPPL, and ORNL. International data links and telephone lines also provide access to smaller 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 includes $700,000 in FY 1993 and FY 1994 in support of FCCSET education activities. It also includes $13,000,000 in FY 1993 and $12,200,000 in FY 1994 for the High Performance Computing and Communication Federal Coordinating Counsel on Science, Engineering, and Technology (FCCSET) initiative. The following table summarizes the operating expenses funding for the Applied Plasma Physics subprogram:

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

Program Activity	FY 1992 Enacted	FY 1993 Enacted	FY 1994 Request	% Change
Fusion Plasma Theory..........................	$ 19,137	$ 19,400	$ 18,800	- 3
Experimental Plasma Research....................	26,460	26,750	26,000	- 3
MFE Computing..................................	16,153	15,710	15,005	- 4
Total, Magnetic Fusion Energy - Applied Plasma Physics	$ 61,750	$ 61,860	$ 59,805	- 3

II. B. Major Laboratory and Facility Funding

LAWRENCE LIVERMORE NATIONAL LABORATORY	$ 15,721	$ 15,255	$ 14,295	- 6
LOS ALAMOS NATIONAL LABORATORY	$ 2,533	$ 2,580	$ 2,505	- 3
OAK RIDGE NATIONAL LABORATORY	$ 4,544	$ 4,280	$ 4,370	+ 2
PRINCETON PLASMA PHYSICS LABORATORY	$ 4,134	$ 4,120	$ 3,780	- 8

III. Activity Descriptions: (Budget Obligations in thousands of dollars)

Program Activity	FY 1992	FY 1993	FY 1994
Magnetic Fusion Energy - Applied Plasma Physics			
Fusion Plasma Theory	Maintained emphasis on improved understanding of transport in toroidal devices. Developed new techniques for data analysis and for visualization of toroidal plasma models. Resolved issues on stabilization of small scale instabilities for burning plasmas.	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 with reduced level of effort on improved understanding of transport in toroidal devices. Initiate the development of simulation models of plasma transport using new techniques and massively parallel computers. Test models of transport and small scale instabilities through comparisons with operating tokamaks.
	Continued theory development in support of ITER with emphasis on alpha particle theory, and RF heating effects.	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 theory development and application in support of ITER with emphasis on alpha particle stability and transport. Develop realistic models for RF heating and profile control. Apply models of transport of heat and particles in magnetic divertors to the design of the ITER divertor.
	Maintained contact with foreign alternate concept theory programs and applied alternate concept developments related to tokamak improvement ideas.	Maintain contact with foreign alternate concept theory programs and apply alternate concept developments related to tokamak improvement ideas.	Maintain contact with foreign alternate concept theory programs and apply alternate concept developments related to tokamak improvement ideas.
	$ 19,137	$ 19,400	$ 18,800
Experimental Plasma Research	Evaluated ion method of helicity injection current drive. Decided to construct a multi-pulse compact toroid injector. Completed work on alternate concept devices and applied ideas to tokamak improvements. Carried out studies of the spherical tokamak concept.	Evaluate RF method of helicity injection current drive. Construct laboratory scale multi-pulse compact toroid injection. 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 tokamaks at PPPL and high aspect ratio tokamaks at Columbia University. 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.

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

Program Activity	FY 1992	FY 1993	FY 1994
Experimental Plasma Research (Cont'd)	Studied transport mechanisms associated with various confinement modes using a heavy ion beam probe and related diagnostics on TEXT in an electron cyclotron heated plasma.	Begin to study transport mechanisms in the TEXT Upgrade Facility using a new higher energy heavy ion beam probe and related diagnostics in electron cyclotron heated plasmas.	Extend studies of transport mechanisms in the TEXT Upgrade Facility to various confinement modes using the new divertor geometry plasmas with higher levels of electron cyclotron heating.
	Conducted proof-of-principle tests for alpha particle diagnostic systems. Enhanced efforts to adapt advanced diagnostics to ITER.	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. Develop advanced diagnostic techniques for applications in ITER.
	Continued basic experiments in small stellarators and tokamaks with emphasis on understanding effects of plasma electrical potentials and methods of controlling current.	Continue basic experiments in small stellarators, reversed field pinch experiments and tokamaks with emphasis on tokamak improvements. Initiate small-scale experiments on new concepts for more attractive reactors.	Evaluate physics of the reverse field pinch-to-tokamak transition region at the University of Wisconsin. Initiate compact toroid acceleration experiments at the University of Washington. Continue stellarator research at the University of Wisconsin and Auburn University. Continue to investigate new concepts for more attractive reactors.
	Continued plasma edge physics and core fluctuation measurements related to transport on major tokamaks using newly developed diagnostics.	Continue plasma edge physics and core fluctuation measurements related to the transport process on major tokamaks using advanced diagnostics and collaborations.	Continue selected plasma edge physics and core fluctuation measurements related to transport on major tokamaks using advanced diagnostics and collaborations.
	Continued excitation and ionization measurements of impurities found in the plasma. Extended atomic data compilation, under international guidelines, to support design of ITER edge plasma control techniques.	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.	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.
	$ 26,460	$ 26,750	$ 26,000

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

Program Activity	FY 1992	FY 1993	FY 1994
MFE Computing	In cooperation with the Office of Energy Research's Scientific Computing Staff (SCS), operated the NERSC with two Cray 2s, and one Cray-YMP computer. Used a proportionate share of time on these computers for activities throughout the Office of Fusion Energy. Purchased "workstation" computers for local computing at fusion sites.	In cooperation with SCS, operate the NERSC with one Cray-YMP, two Cray 2s, and one C-90 computer. Use a proportionate share of time on these computers for activities throughout the Office of Fusion Energy. Support specific computer code developments in new high performance computers for tokamak simulation.	In cooperation with SCS program, operate the NERSC with one Cray-YMP, two Cray 2s, and one C-90 computer. Use a proportionate share of time on these computers for activities throughout the Office of Fusion Energy. Support specific computer code developments using new high performance computer for tokamak simulation.
	$ 16,153	$ 15,710	$ 15,005
Magnetic Fusion Energy - Applied Plasma Physics	$ 61,750	$ 61,860	$ 59,805

DEPARTMENT OF ENERGY
FY 1994 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. 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 and will continue to be sought 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 1994 will be a continuation of those assigned by and negotiated with the ITER Director and approved by the ITER Council in FY 1993.

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 principal focus of these activities is ITER, although development in support of existing and near term devices, such as D-III-D and TPX, is also 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 and negative ion neutral beams. 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

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

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 hazards associated with radioactive products associated with fusion reactors and is primarily focused on ITER.

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; the neutral beam test facilities at Lawrence Berkeley 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.

This budget includes $14,400,000 in FY 1993 and $13,500,000 in FY 1994 for the Advanced Materials and Processing FCCSET initiative.

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

Program Activity	FY 1992 Enacted	FY 1993 Enacted	FY 1994 Request	% Change
ITER	$ 39,164	$ 47,845	$ 62,400	+ 30
Plasma Technologies	6,258	6,297	6,550	+ 4
Fusion Technologies	8,878	9,260	9,450	+ 2
Fusion Systems Studies	2,350	2,998	2,900	- 3
Total, Magnetic Fusion Energy - Development and Technology	$ 56,650	$ 66,400	$ 81,300	+ 22

II. B. Major Laboratory and Facility Funding

ARGONNE NATIONAL LABORATORY (EAST)	$ 4,368	$ 5,968	$ 4,440	- 26
LAWRENCE LIVERMORE NATIONAL LABORATORY	$ 9,699	$ 8,105	$ 4,365	- 46
LOS ALAMOS NATIONAL LABORATORY	$ 3,134	$ 3,624	$ 3,390	- 6
OAK RIDGE NATIONAL LABORATORY	$ 11,257	$ 10,697	$ 9,980	- 7
PACIFIC NORTHWEST LABORATORY	$ 3,412	$ 3,485	$ 3,310	- 5
SANDIA NATIONAL LABORATORIES	$ 4,630	$ 4,903	$ 5,510	+ 12

III. Activity Descriptions: (Budget Obligations in thousands of dollars)

Program Activity	FY 1992	FY 1993	FY 1994
Magnetic Fusion Energy - Development and Technology			
ITER	In the magnet area, testing of ITER superconducting samples in FENIX facility was carried out. Design and analysis of ITER model coils began.	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 is initiated. 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 and preparation for cabling the strands will begin. Testing of full size, short samples of U.S. superconducting cable for ITER will begin. Structural material tests will continue.
	In the heating area, development of a negative ion source and gyrotron tubes for ITER application was continued.	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 also continue.
	In the fueling area, development of an ITER pellet injector was continued.	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, tests on high Z materials for ITER was continued. Innovative divertor designs were evaluated for ITER. ITER erosion and redeposition tests were continued. A program on disruption simulation was initiated.	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 developed and prototype small fabrication models will begin. Tests will continue on beryllium, carbon and high Z materials. Erosion, redeposition and disruption simulation tests will continue.

Program Activity	FY 1992	FY 1993	FY 1994
ITER (Cont'd)	Critical questions on ITER reference materials were experimentally investigated in irradiation and corrosion tests designed to explore ITER conditions.	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 structural materials for first wall/blanket/shield and divertor will be conducted to fulfill ITER agreements. These will include irradiation tests, compatibility studies, data base generation, and fabrication studies on austenitic stainless steels, copper alloys, niobium alloys, and/or other material classes.
	Blanket/shield work was focused on activities to prepare for major initiatives in ITER research, including a non-nuclear facility for thermo-mechanical and thermal-hydraulic testing of blanket module prototypes and a blanket module for neutron irradiation in a Russian fission reactor.	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 subscale 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 subscale blanket/shield prototypic modules and of nuclear testing with neutronic mock-ups exposed to a small 14 MeV neutron source in Japan.
	Operated TSTA to provide data for and validation of the existing ITER fuel cycle design.	Operate 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.
	ITER environment and safety activities established the basis for work to produce the safety and regulatory-quality data base required for the ITER design activity. Tritium, activation products, and magnet safety issues were included.	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 safer.	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 be developed.
	Preparation for assembly and maintenance and containment structure assignments were started.	Assembly and 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.

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

Program Activity	FY 1992	FY 1993	FY 1994
ITER (Cont'd)	No activity.	No activity.	U.S. assigned tasks on evaluation of the irradiation and service performance of ceramic and glass materials for use in electircal insulation, optical or rf window, and electrical or optical transmission components will be conducted.
	Began engineering design preparations for ITER on a four-party basis. Work during 1992 includes beginning engineering design and analysis and the analysis to improve the overall design of a scaleable superconducting magnet model.	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 for management of the U.S. ITER home team and establishment of 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.
	$ 39,164	$ 47,845	$ 62,400
Plasma Technologies	Ordered advanced superconducting wire.	Superconducting wire characterization tests and magnet analysis will be conducted.	Superconducting wire characterization tests and magnet analysis will be conducted, and prototype conductors fabricated. Development support for TPX magnets will be provided.
	In the heating area, completed test of pulsed 1 MW gyrotron. Completed tests of 0.5 MW, 1 second tube.	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.	In the heating area, development 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.

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

Program Activity	FY 1992	FY 1993	FY 1994
Plasma Technologies (Cont'd)	In the fueling area, work on advanced fueling techniques was carried out.	Advanced high speed pellet injectors will be developed and tested.	Two stage high speed pellet injectors will be developed.
	In the plasma materials interaction area, TFTR support was continued for international collaborations on TEXTOR, ASDEX-U, and Tore Supra.	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.
	$ 6,258	$ 6,297	$ 6,550
Fusion Technologies	Continued international cooperation on TSTA testing program.	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 system components and system.	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 testing of ceramic tritium breeding materials.
	In the environment and safety program, continued with experimental and analytical efforts in tritium, activation products, blankets, and magnet areas, focusing on key safety issues.	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 of TPX will be initiated.

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

Program Activity	FY 1992	FY 1993	FY 1994
Fusion Technologies (Cont'd)	Neutron interactive materials program continued using available fission reactors and other materials evaluation technologies. Alloy modifications to improve properties were evaluated. Collaborative programs with Japan and IEA partners maximize the limited program resources.	Materials for first wall/blanket/shield structures, for use in heating systems, divertor structures, and diagnostic systems will be under study using fission reactors and particle accelerators to evaluate irradiation resistance. Modifications of compositions and microstructures to improve properties and to enhance resistance to irradiation will continue to be evaluated. Materials that meet revised low activation criteria will be developed. 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 enhanced. Two collaborations with Japan will continue.
	Fusion neutron source scoping studies were initiated to explore accelerator-based approaches and determine critical issues for future evaluation.	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 or other enabling agreement. Critical design and testing issues will be under investigation.
	$ 8,878	$ 9,260	$ 9,450
Fusion Systems Studies	Completed ARIES studies and initiated studies of non-steady-state tokamak power reactors and fusion power demonstration facilities.	Continue non-steady-state study. Initiate stellarator reactor studies and tokamak demonstration power plant study with enhanced industrial team involvement.	Continue study of stellarator reactor and demonstration power plant requirements.
	$ 2,350	$ 2,998	$ 2,900
Magnetic Fusion Energy - Development and Technology	$ 56,650	$ 66,400	$ 81,300

DEPARTMENT OF ENERGY
FY 1994 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 1992 Enacted	FY 1993 Enacted	FY 1994 Request	% Change
Planning and Projects	$ 337	$ 4,800	$ 4,895	+ 2
Total, Planning and Projects	$ 337	$ 4,800	$ 4,895	+ 2

III. Activity Descriptions: (Budget Obligations in thousands of dollars)

Program Activity	FY 1992	FY 1993	FY 1994
Planning and Projects	Funding in the amount of $3,913,000 has been transferred to the SBIR program.	Funding in the amount of $4,562,000 has been budgeted for the SBIR program.	Funding in the amount of $4,611,000 has been budgeted for the SBIR program.
	$ 337	$ 4,800	$ 4,895
Planning and Projects	$ 337	$ 4,800	$ 4,895

DEPARTMENT OF ENERGY
FY 1994 CONGRESSIONAL BUDGET REQUEST
ENERGY SUPPLY, RESEARCH AND DEVELOPMENT
(dollars in thousands)

KEY ACTIVITY SUMMARY

FUSION ENERGY

I. Preface: Inertial Fusion Energy

Recent successes in inertial confinement fusion tests have 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 budget subprogram, Inertial Fusion Energy (IFE), to develop the potential of inertial fusion as an energy source. The IFE 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 the Inertial Confinement Fusion (ICF) activity in the Office of Defense Programs and has extended the Heavy Ion Fusion Accelerator Research (HIFAR) that previously was undertaken elsewhere within the Office of Energy Research. ICF 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 HIFAR activities, previously funded in the Basic Energy Sciences program, have been transferred to this new Inertial Fusion Energy subprogram within the Fusion Energy program in FY 1992.

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 about 100 times the energy required to compress the capsule. The compression driving source must have energy efficiency of approximately 10% 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 could 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 Studies (ILSE) has been proposed and conceptual design prepared. While construction funding for ILSE is not requested in FY 1994, preparations for a heavy-ion driver facility continue. In FY 1993, in response to the Department, the Fusion Energy Advisory Committee will recommend an IFE program that could be carried under realistic budget projections. For FY 1994, methods to reduce cost and risk of heavy ion beam and driver development will be explored. International cooperation on IFE driver research will be sought.

In FY 1994, 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 and the integration of target designs with reactor concepts may be part of the IFE activities in FY 1994.

II. A. Summary Table: Inertial Fusion Energy

Program Activity	FY 1992 Enacted	FY 1993 Enacted	FY 1994 Request	% Change
Heavy Ion Beams................................	$ 6,757	$ 6,850	$ 1,200	- 82
Driver Concept Development......................	0	0	2,000	>999
Targets for IFE................................	0	0	800	>999
Reactor Technology.............................	1,393	0	0	0
Total, Inertial Fusion Energy	$ 8,150	$ 6,850	$ 4,000	- 42

II. B. Major Laboratory and Facility Funding

LAWRENCE BERKELEY LABORATORY	$ 5,423	$ 4,860	$ 2,550	- 48
LAWRENCE LIVERMORE NATIONAL LABORATORY	$ 1,050	$ 1,200	$ 960	- 20

III. Activity Descriptions: (Budget Obligations in thousands of dollars)

Program Activity	FY 1992	FY 1993	FY 1994
Inertial Fusion Energy			
Heavy Ion Beams	Heavy Ion Accelerator Physics (previously funded in the Basic Energy Sciences program) continued with emphasis on beam quality and merging techniques. Research and development continued and a conceptual design was prepared for the Induction Linac Systems Experiment (ILSE).	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 has been made not to proceed with construction of the ILSE accelerator in FY 1994. Efforts will be directed toward technology improvements and testing of accelerator modules and pulsed power systems. Development and testing of a full-scale alkali ion beam source and injector will be continued.
	$ 6,757	$ 6,850	$ 1,200

III. Inertial Fusion Energy (Cont'd):

Program Activity	FY 1992	FY 1993	FY 1994
Driver Concept Development	No activity.	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 focussing. High performance computers and improved codes can predict detailed ion beam performance, in particular, with advance in simulation of magnetic bending and focussing expected.
	$ 0	$ 0	$ 2,000
Targets for IFE	No activity.	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.
	$ 0	$ 0	$ 800
Reactor Technology	Completed two conceptual design studies of IFE reactors. These results were used as a basis for extended reactor concept development. Research and development was initiated to validate these concepts in future years.	Complete written reports.	No activity.
	$ 1,393	$ 0	$ 0
Inertial Fusion Energy	$ 8,150	$ 6,850	$ 4,000

DEPARTMENT OF ENERGY
FY 1994 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. This program supports the energy mission contained in the Energy Policy Act of 1992 and the plans developed within the Department. 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 1992 Enacted	FY 1993 Enacted	FY 1994 Request	% Change
Salaries and Expenses	$ 6,328	$ 7,650	$ 7,735	+ 1
Other	1,172	1,150	1,465	+ 27
Total, Program Direction	$ 7,500	$ 8,800	$ 9,200	+ 5

III. Activity Descriptions: (Budget Obligations in thousands of dollars)

Program Activity	FY 1992	FY 1993	FY 1994
Program Direction			
Salaries and Expenses	Provided funds for salaries, benefits, and travel for 78 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 80 FTEs.	Provide funds for salaries, benefits, and travel for 81 FTEs.
	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; oversight of construction and operation of scientific R&D facilities; ES&H oversight and HQ coordination in preparation for TFTR deuterium-tritium (D-T) operation; and conduct of interagency and international liaison and negotiations, including the ITER EDA negotiations. Managed magnetic fusion energy programs and a new program involving Inertial Fusion Energy (IFE). Redirected design activities from the Burning Plasma Experiment (BPX) project to the Tokamak Physics Experiment (TPX) to address tokamak improvements. Conducted physics experiments in support of the ITER design effort. Managed ongoing program activities consistent with the National Energy Strategy goal of securing future energy supplies and Departmental initiatives. Ensured compliance of programs with ES&H regulations. Continued international collaboration to avoid duplication of	Continue program management activities as in FY 1992. Support ITER and IFE activities. Manage ongoing programs in magnetic fusion energy including programs to improve the tokamak concept and ensure development of inertial fusion energy. Continue ES&H oversight of preparation for and initiation of D-T experiments in TFTR. Continue physics experiments in support of the ITER. Continue establishment of ES&H criteria for ITER. Manage the conceptual design phase of TPX. Manage other ongoing program activities consistent with the program's mission, Departmental priorities, improved contractor oversight, and ES&H regulations. Continue international collaborations relating to ITER and other major program projects. Consider ITER site selection options and prepare recommended Department position regarding site selection.	Continue program management activities as in FY 1993. Support TFTR D-T, ITER, and TPX activities. Continue to manage ongoing programs in magnetic fusion energy, including programs to improve the tokamak concept and ensure inertial fusion energy. Continue physics experiments and establishment of ES&H criteria for ITER. Support enhanced TPX activities, and manage other ongoing program activities consistent with program missions, the Energy Policy Act of 1992, Departmental priorities, and improved contractor oversight. Continue international collaboration on ITER as design and site selection activities intensify. Join with foreign partners in planning for comprehensive program to develop fusion energy, particularly including materials development facilities and related R&D.

III. Program Direction (Cont'd):

Program Activity	FY 1992	FY 1993	FY 1994
Salaries and Expenses (Cont'd)	effort and advance the program in a timely way.		
	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 1992.	Continue to provide program and management support as in FY 1993.
	Supported the magnetic fusion energy activities carried out by the Chicago Field Office, primarily at the Princeton Area Office (PAO). This Area Office is responsible for the operation of DOE's largest fusion laboratory, the Princeton Plasma Physics Laboratory, which operates the TFTR facility. Began to implement the Tiger Team action plan for strengthening ES&H oversight at the site and strengthening overall contract management oversight.	Continue to support magnetic fusion energy activities carried out by the Chicago Field Office, primarily at the Princeton Area Office. Continued to strengthen ES&H and contract management oversight at the site.	Continue to support magnetic fusion energy activities carried out by the Chicago Field Office, primarily at the Princeton Area Office. Provide increased support for the expanded TPX activities to ensure compliance with technical/engineering standards and to address technical issues.
	Supported magnetic fusion energy activities at the San Francisco Field Office.	Continue to support magnetic fusion energy activities at the San Francisco Field Office.	Continue to support magnetic fusion energy activities at the San Francisco Field Office.
	$ 6,328	$ 7,650	$ 7,735
Other	Provided funds for a variety of program support services such as printing and editing, and contractual support, for example, for timesharing on various information systems and communications networks. Also provided support for the employees at Chicago and San Francisco Field Offices who were reassigned to ER.	Continue the variety of program support required in FY 1992, including permanent changes of station and automated office support system workstations.	Continue the variety of program support required in FY 1993. Provide increased support to ensure compliance with environment, safety, and health regulations.

III. Program Direction (Cont'd):

Program Activity	FY 1992	FY 1993	FY 1994
Other (Cont'd)	$ 1,172	$ 1,150	$ 1,465
Program Direction	$ 7,500	$ 8,800	$ 9,200

DEPARTMENT OF ENERGY
FY 1994 CONGRESSIONAL BUDGET REQUEST
ENERGY SUPPLY, RESEARCH AND DEVELOPMENT
(dollars in thousands)

KEY ACTIVITY SUMMARY

FUSION ENERGY

I. Preface: Capital Equipment

The capital equipment revised request for FY 1994 of $15,995,000 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 initiated. 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 1992 Enacted	FY 1993 Enacted	FY 1994 Request	% Change
Confinement Systems	$ 6,750	$ 6,700	$ 11,400	+ 70
Applied Plasma Physics	550	550	395	- 28
Development and Technology	4,850	6,000	4,200	- 30
Inertial Fusion Energy	850	850	0	-100
Total, Capital Equipment	$ 13,000	$ 14,100	$ 15,995	+ 13

II. B. Major Laboratory and Facility Funding

LAWRENCE LIVERMORE NATIONAL LABORATORY	$ 2,465	$ 2,280	$ 750	- 67
OAK RIDGE NATIONAL LABORATORY	$ 2,240	$ 2,165	$ 1,750	- 19
PRINCETON PLASMA PHYSICS LABORATORY	$ 3,020	$ 1,030	$ 800	- 22

III. Activity Descriptions: (Budget Obligations in thousands of dollars)

Program Activity	FY 1992	FY 1993	FY 1994
Capital Equipment			
Confinement Systems	Provided support for experimental operations of existing devices. Continued 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, 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, 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.
	Modified the existing TFTR deuterium pellet injector to make it capable of injecting one pellet at higher velocity.	Complete modification of the TFTR pellet injector to make compatible with tritium. Provide funds to upgrade the heating and current drive systems on PBX-M.	Advance capability of DIII-D to enable it to carry out ITER physics R&D by the design and procurement of several major items of equipment including: the radiative divertor (estimated TEC $14.9 million), increase in 110 GHz ECH power (estimated TEC $25.0 million), an upgrade in the Fast Wave Current Drive power (estimated TEC $13.0 million), and upgrade of the DIII-D tokamak system for 10 sec operations (estimated TEC $16.0 million).
	$ 6,750	$ 6,700	$ 11,400
Applied Plasma Physics	Provided 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.	Provide general laboratory equipment for experimental research at national laboratories including computing equipment.
	$ 550	$ 550	$ 395
Development and Technology	Special and general purpose equipment was 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.

III. Capital Equipment (Cont'd):

Program Activity	FY 1992	FY 1993	FY 1994
Development and Technology (Cont'd)	$ 4,850	$ 6,000	$ 4,200
Inertial Fusion Energy	Equipment funds were 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	$ 850	$ 0
Capital Equipment	$ 13,000	$ 14,100	$ 15,995

DEPARTMENT OF ENERGY
FY 1994 CONGRESSIONAL BUDGET REQUEST
ENERGY SUPPLY, RESEARCH AND DEVELOPMENT
(dollars in thousands)

KEY ACTIVITY SUMMARY

FUSION ENERGY

I. Preface: Construction

II. A. Summary Table: Construction

Program Activity	FY 1992 Enacted	FY 1993 Enacted	FY 1994 Request	% Change
General Plant Projects..........................	$ 1,950	$ 2,000	$ 2,000	0
Fire & Safety Protection Improvements...........	2,600	2,200	0	-100
Tokamak Physics Experiment......................	0	0	13,000	>999
Total, Construction	$ 4,550	$ 4,200	$ 15,000	+257

III. Activity Descriptions: (Budget Obligations in thousands of dollars)

Program Activity	FY 1992	FY 1993	FY 1994
Construction			
General Plant Projects	Supported 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 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.
	$ 1,950	$ 2,000	$ 2,000
Fire & Safety Protection Improvements	Provided for initiation of a project to correct fire and safety deficiencies at the Princeton Plasma Physics Laboratory.	Provides for completion of a project to correct fire and safety deficiencies at the Princeton Plasma Physics Laboratory.	No activity.
	$ 2,600	$ 2,200	$ 0
Tokamak Physics Experiment	No activity.	No activity.	The TPX project will commence Title I design activities in FY 1994 including procurement of architect engineering services. Proceeding with this device now is critical to maintaining the program vitality after TFTR is shut down. Provides $13 million of the $20 million as part of the President's Economic Investment package for TPX.
	$ 0	$ 0	$ 13,000
Construction	$ 4,550	$ 4,200	$ 15,000

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 Appropriated	FY 1994 Request	Unappropriated Balance	TEC
94-E-200	Tokamak Physics Experiment (A-E Design Only)	$ 0	$ 0	$ 13,000	$ 0	$ 13,000
92-E-340	Fire & Safety Protection Improvements at PPPL	2,600	2,200	0	0	4,800
GPE-900	General Plant Projects	XXX	2,000	2,000	0	2,000
Total, Fusion Energy		$ XXX	$ 4,200	$ 15,000	$ 0	$ 19,800

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: $13,000
TPC: $32,800 a/

Start Date: 1st Qtr. FY 1994 Completion Date: TBD

2. Financial Schedule (Federal Funds):

Fiscal Year	Appropriated	Obligations	Costs
1994	$ 13,000	$ 13,000	$ 13,000

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 1994 is for start of Title I Design of the project in preparation for a full project budget request in 1995.

4. Total Project Funding (BA):

	Prior Years	FY 1992	FY 1993	FY 1994 Request
Construction	$ 0	$ 0	$ 0	$13,000
Capital Equipment	0	0	0	0
Operating Expenses	0	1,000	11,800	7,000

a/ The preliminary Total Project Cost estimate is approximately $500 million in FY 1992 dollars. A project quality estimate will be available upon completion of the current conceptual design effort. For planning purposes, a funding profile has been developed for this project which includes $70.0 million in FY 1995, $91.0 million in FY 1996, $95.0 million in FY 1997, and $96.0 million in FY 1998 with the balance beyond FY 1998.

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 1994 Completion Date: 4th Qtr. FY 1995

2. Financial Schedule (Federal Funds):

Fiscal Year	Appropriated	Obligations	Costs
1994	$ 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 1992	FY 1993	FY 1994 Request
Construction	$ 0	$ 1,950	$ 2,000	$ 2,000

DEPARTMENT OF ENERGY
FY 1994 CONGRESSIONAL BUDGET REQUEST

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

Fusion Energy

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

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

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

5. Previous Cost Estimate: None

3b. A-E Work (Title I & II) Duration: 30 Months (Title I Only)

4a. Date Physical Construction Starts: TBD

4b. Date Construction Ends: TBD

6. Current Cost Estimate:
TEC -- $13,000
TPC -- $32,800 a/

7. Financial Schedule (Federal Funds):

Fiscal Year	Appropriation	Obligations	Costs
1992	$ 0	$ 0	$ 0
1993	0	0	0
1994	13,000	13,000	13,000

* 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.

a/ The preliminary Total Project Cost estimate is approximately $500 million in FY 1992 dollars. A project quality estimate will be available upon completion of the current conceptual design effort. For planning purposes, a funding profile has been developed for this project which includes $70.0 million in FY 1995, $91.0 million in FY 1996, $95.0 million in FY 1997, and $96.0 million in FY 1998 with the balance beyond FY 1998.

1. Title and Location of Project:	Tokamak Physics Experiment (TPX) Princeton Plasma Physics Laboratory (PPPL) Plainsboro, New Jersey* (DESIGN ONLY)	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 a steady state advanced tokamak experimental facility. 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.

Construction of the TPX facility will include the following new facilities: moderate magnetic field tokamak device with support structure, vacuum vessel, vacuum pumping system, superconducting magnet coils, support systems, and an on-site helium refrigeration plant.

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

The purpose of the U.S. Magnetic Fusion program is to build the scientific and technological base required to determine whether fusion can become a viable energy source for deployment in the 21st Century. Two key science issues in establishing this fusion scientific base are extending the tokamak concept to the steady state regime and pursuing advances in tokamak physics. TPX has a dual mission of steady state and advanced tokamak operation. It is designed to develop and demonstrate optimized steady state tokamak operating modes. The central role of TPX is to point the way to a more attractive demonstration reactor DEMO than the present inventory of devices can support.

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

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 deuterium-tritium nuclear fuel cycle and a burning plasma. It would test high-duty-factor plasma operation, non-inductive current drive, power and particle handling, and disruption control in an integrated manner. It would seek to significantly improve the physics of tokamaks 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 advance reactor technologies including superconducting magnets, high-heat-flux divertors, steady state plasma heating and

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

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

current drive systems, and remote maintenance. In summary, the TPX would be an important and exciting experiment to advance fusion energy development in the United States and in the world.

The TPX project provides a new tokamak device in the existing TFTR test cell, following TFTR shutdown and decommissioning.

The funding request of $13,000,000 in FY 1994 is for start of the preliminary design on the TPX project in preparation for a full project budget request for FY 1995.

10. Details of Cost Estimate

	Item Cost	Total Cost
a. 1. Engineering design, inspection & administration (DESIGN ONLY Request).........	$ 12,000	
2. Project management (DESIGN ONLY Request)..	$ 1,000	
b. Construction costs (N/A at this time-DESIGN ONLY Request).........................		
c. Removals and maintaining production costs (N/A at this time-DESIGN ONLY Request)...		
d. Standard equipment (N/A at this time-DESIGN ONLY Request).........................		
e. Design and project liaison, testing, checkout and acceptance (N/A at this time)....		
Subtotal..		$ 13,000
f. Contingencies (N/A at this time-DESIGN ONLY Request).............................		
Total line item cost (Section 12.a.1)..		$ 13,000
g. Non-Federal contribution..		

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

11. Method of Performance

The design engineering for TPX will be an effort involving the participation of several national laboratories, other DOE research centers, and private industry. 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 and to enable all program participants to benefit from the TPX technical and scientific challenges and progress. The design of conventional facilities will be accomplished by a negotiated architect-engineer contract. The design of special facilities will be by PPPL, LLNL, MIT, ORNL, LANL, and industrial contractors. PPPL will procure the services of a systems integration contractor for the overall design integration and configuration control.

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

	FY92	FY93	FY94
a. Total Project Funding			
1. Total facility costs			
(a) Line item (Section 10)	$ 0	$ 0	$ 13,000
2. Other project costs			
(a) R&D necessary to complete project	0	700	5,000
(b) Conceptual design costs			
(1) Pre-Conceptual Design	900	0	0
(2) Conceptual Design	0	5,600	0
(3) Advanced Conceptual Design	0	3,700	0
(c) Decontamination & Decommissioning	0	0	0
(d) Site Characterization	0	0	0
(e) NEPA Documentation costs	0	200	0
(f) Other project related costs	100	1,600	2,000
(g) Non-Federal contribution	0	0	0
Total other project costs	$ 1,000	$11,800	$ 7,000
Total project cost (TPC)	$ 1,000	$11,800	$20,000

b. Related annual funding - Not applicable at this time: DESIGN ONLY Request

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

a. Total project funding (DESIGN ONLY)
  1. Total Facility Costs - Description is provided in Sections 8 and 9.
    (a) Line item -- Narrative not required.
    (b) PE&D -- None.
    (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 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. The project also depends upon the continued role of the fusion laboratories, universities, and industrial partners to support the technology research and development activities necessary to successfully complete TPX.
    (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 needs. 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) NEPA documentation costs are to prepare an Environmental Assessment for construction and operation of TPX.
    (d) Other project related costs include physics design support.

b. Related annual funding
Not applicable at this time: DESIGN ONLY Request.

DEPARTMENT OF ENERGY
FY 1994 CONGRESSIONAL BUDGET REQUEST

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 1994

5. Previous Cost Estimate: None

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

4a. Date Physical Construction Starts: 3rd Qtr. FY 1994

4b. Date Construction Ends: 4th Qtr. FY 1995

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

7. Financial Schedule (Federal Funds) :

		Costs			
Fiscal Year	Obligations	FY 1992	FY 1993	FY 1994	After FY 1995
Prior Year Projects	$- 3,000 a/	$ 1,773	$ 0	$ 0	$ 0
1992 Projects	1,950	1,800	150	0	0
1993 Projects	2,000	0	1,850	150	0
1994 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

a/ Reflects reprogramming of $3,000,000 from Fusion Energy to Basic Energy Sciences for the Solid State Research Facility.

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 1994 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............	$ 370
Seismic Reinforcement for PLT/PBX-M Shielding Walls..........................	$ 230
Modification of Facilities for Handicapped Accessibility.....................	$ 300
Site Improvements and Utility Service Upgrades...............................	$ 320
Facility Maintenance Building Annex..	$ 350
Roofing System Replacements..	$ 180
Electric Power Modifications...	$ 250

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.