DEPARTMENT OF ENERGY
FY 1990 CONGRESSIONAL BUDGET REQUEST
OFFICE OF ENERGY RESEARCH

OVERVIEW

MAGNETIC FUSION ENERGY

The goal of the National Energy Policy Plan (NEPP) is to assure an adequate supply of energy at reasonable cost. The Magnetic Fusion program is an important part of the Department's efforts to achieve this goal in the long term. The program is being conducted according to the Magnetic Fusion Program Plan (MFPP) which was developed in 1985. The main goal of the magnetic fusion program is to establish the scientific and technological base required for an assessment of the feasibility of fusion energy. This goal was chosen with consideration of the constraints on Federal spending, the variable energy supply situation, and the excellent technical progress in fusion research. The MFPP takes full advantage of the budgetary and scientific leverage to be gained through international collaboration. It also recognizes the importance of fusion as a means to improve relations with other nations. The MFPP has been accepted by the fusion community.

The strategy for providing this scientific and technological base is two-fold: (1) maintenance of a domestic R&D program that covers the necessary range of fusion science and technology adequately, and (2) use of international collaboration to advance the program in a timely way, especially through joint projects.

The remaining work that must be accomplished to reach the program goal can be summarized by defining four key technical issues. The issues are associated with determining the properties of burning plasmas, improving magnetic confinement systems, formulating fusion materials and developing fusion nuclear technology. These issues have been agreed to by the Economic Summit Member's Fusion Working Group as the focus for planning future international research facilities. The U.S. program research on these issues constitutes the basis for participation in the world fusion program.

The first of these issues concerns the properties of burning plasmas. Understanding the properties of burning plasmas is required to complete the scientific base for fusion. No experimental facility presently exists anywhere in the world to investigate this fundamental issue. Given the resources represented by the scientific personnel and infrastructure at Princeton Plasma Physics Laboratory, the United States is in the best technical position to proceed with such an experiment. As part of joint international planning to avoid needless duplication of costly facilities, the European Community and Japan have encouraged the United States to undertake a Compact Ignition Tokamak (CIT) on a timely basis to complement their extensive programs on the other key technical issues.

The schedule for the CIT project, the architect-engineering design of which was initiated in FY 1988, is influenced by both domestic and international program considerations. A timely U.S. CIT would provide vital information to the world program on how to design, build and operate a full fledged Fusion Engineering Test Reactor in the ignited mode, saving several years of costly exploratory research on such a reactor itself. The Magnetic Fusion Advisory Committee, ERAB, and an international scientific review team have all endorsed the scientific importance of this experiment. The funding proposed in this budget allows the U.S. to use the information base available from current experiments to prepare for its own next step and to retain the possibility of providing a fair contribution to the world fusion program.

The second key technical issue concerns magnetic confinement systems. Significant progress continues to be made in understanding the confinement process. Confinement is now sufficient to achieve energy breakeven and to design an ignition experiment. Improved understanding of confinement, combined with burning plasma physics from the CIT experiment is expected to reduce the cost of development and future application of fusion energy. This budget request provides for an increased emphasis on understanding confinement in tokamaks. Research on this key issue is being closely coordinated internationally to maintain the broadest scientific coverage at minimum cost.

The third key issue concerns the identification and testing of materials for fusion systems. Not only is materials research vital to a successful experimental fusion program today but it is also the key to realizing the benefits of fusion. Materials play a central role in determining the environmental characteristics of a fusion reactor. Achievement of the program goal requires the development of new materials to enhance the economic and environmental potential of fusion. As part of the program's international strategy, this issue is being pursued through cooperative agreements which provide significant foreign contributions toward the operation of U.S. research facilities. The proposed FY 1990 budget supports the core research program needed for U.S. participation in this international effort.

The fourth key issue concerns developing the nuclear technology of fusion systems. This development requires advances in the basic engineering sciences, as well as the application of the results of basic fusion materials research. A fusion blanket performs several functions, including converting the energy released by a fusion reaction into useful energy, creating part of the fuel for the reactor, and allowing for recovery of this fuel, as well as shielding critical machine components from radiation. This issue will be completely resolved only when fuel producing blankets are integrated with other fusion systems and tested in a nuclear environment. This budget supports the basic technology research that underlies the development of blankets for a full fledged Fusion Engineering Test Reactor.

International collaboration has become a major resource for the development of fusion energy. The fusion program has a long history of scientific exchange and cooperation. The Economic Summit process has provided a mechanism for developing an integrated fusion program for the Western allies. Through a series of important international collaborative arrangements the program has made a great deal of progress toward this goal in the past. Following U.S./USSR discussions at the Geneva Summit, in which the Soviets proposed a joint U.S./USSR reactor building project, the U.S. agreed to an international joint effort, including the USSR as well as Japan and the European Community (EC), to develop a single conceptual design for an International Thermonuclear Experimental Reactor (ITER) by the end of 1990, under the IAEA auspices. This year work on ITER was initiated at a level equivalent to $64 million per year, equally supported by the U.S., EC, Japan and the USSR. This budget provides for continued U.S. participation in the conceptual design and validating R&D for an international ITER.

The FY 1990 budget request attempts to accommodate the Congressional mandate to maintain a strong domestic fusion program while recognizing the need to constrain fiscal expenditures. This focus of the fusion program will be on ignition physics issues and improved understanding of confinement. It also gives a high priority to improving our understanding of tokamak confinement and how confinement could be improved. Deuterium-Tritium preparation on TFTR will be delayed to allow experiments focused on confinement to continue. The Princeton Beta Experiment (PBX) facility will be mothballed and the mirror program completed. Technology development needs for TFTR, CIT and ITER will be supported. Longer range materials research and the nuclear technology program will continue at the basic research level. Magnetic confinement improvement experiments will continue with reliance placed on international collaboration to cover some of the scientific issues. Overall U.S. efforts will be pursued at minimal levels and will be augmented significantly through international collaboration.

In summary, this budget provides for a minimum level U.S. fusion program focused clearly on the key technical issues and interwoven tightly with other world fusion programs through international collaboration. The focus is on ignition physics issues based on TFTR and CIT. Experimental efforts aimed at improving toroidal confinement will be intensified and an awareness program in fusion technology will continue.

DEPARTMENT OF ENERGY
FY 1990 CONGRESSIONAL BUDGET REQUEST
ENERGY SUPPLY RESEARCH AND DEVELOPMENT
OFFICE OF ENERGY RESEARCH
(dollars in thousands)

LEAD TABLE

Magnetic Fusion Energy

Activity	FY 1988 Actual	FY 1989 Estimate	FY 1990 Base	FY 1990 b/ Request	Program Change Request vs Base: Dollar	Program Change Request vs Base: Percent
Operating Expenses						
Confinement Systems..........	$159,605	$174,754	$174,754	$168,150	$- 6,604	- 4
Applied Plasma Physics.......	74,775	78,155	78,155	73,215	- 4,940	- 6
Development and Technology...	55,915	54,145	54,145	56,700	+ 2,555	+ 5
Planning and Projects........	869	5,000	5,000	4,900	- 100	- 2
Program Direction...........	4,600	4,600	4,600	5,000	+ 400	+ 9
Subtotal Operating Expenses..	295,764	316,654	316,654	307,965	- 8,689	- 3
Capital Equipment............	18,685	21,635	21,635	13,185	- 8,450	- 39
Construction.................	16,900	12,400	12,400	28,100	+15,700	+127
Total........................	331,349 a/	350,689	350,689	349,250	- 1,439	0

Activity	FY 1988 Actual	FY 1989 Estimate	FY 1990 Base	FY 1990 b/ Request	Program Change Request vs Base Dollar	Percent
Operating Expenses............	(295,764)	(316,654)	(316,654)	(307,965)	- 8,689	- 3
Capital Equipment.............	(18,685)	(21,635)	(21,635)	(13,185)	- 8,450	- 39
Construction..................	(16,900)	(12,400)	(12,400)	(28,100)	+15,700	+127
Staffing (FTEs)...............	62	62	62	62		

Authorization: Section 209, P.L. 95-91

a/ Total has been reduced by $3,651,000 which has been transferred to the SBIR program.
b/ The Confinement Physics Research Facility is proposed as a line item construction project. This project was authorized and appropriated as an operating expense funded project through FY 1989.

DEPARTMENT OF ENERGY
FY 1990 CONGRESSIONAL BUDGET REQUEST
ENERGY SUPPLY RESEARCH AND DEVELOPMENT
(dollars in thousands)

SUMMARY OF CHANGES

Magnetic Fusion Energy

FY 1989 Appropriation	$ 350,689
<u>Operating Expenses</u>	
- The research effort is focused on priority items to understand tokamak confinement: the Princeton Beta Experiment (PBX) (shaped plasma) will be mothballed and the Advanced Toroidal Facility operating time is reduced. D-T preparations on TFTR will also be delayed. In addition, the Confinement Physics Research Facility (CPRF) at LANL has been transferred from an operating expense funded project to a line item construction project	- 8,689
<u>Capital Equipment</u>	
- Construction of the CPRF will be supported under the construction account. Procurement of some lower priority items of equipment will be deferred	- 8,450
<u>Construction</u>	
- This increase provides for continuation of the design effort on the Compact Ignition Tokamak. Also included is the construction effort on the CPRF	+ 15,700
FY 1990 Congressional Budget Request	$ 349,250

DEPARTMENT OF ENERGY
FY 1990 CONGRESSIONAL BUDGET REQUEST
ENERGY SUPPLY RESEARCH AND DEVELOPMENT
(dollars in thousands)

KEY ACTIVITY SUMMARY

MAGNETIC FUSION ENERGY

I. Preface: Confinement Systems

The Confinement Systems subprogram addresses two of the four key technical issues - improving magnetic confinement systems and determining the properties of burning plasmas. These issues are investigated through experimental research on controlling and heating the plasmas required for a magnetic fusion energy source. This research is conducted primarily on toroidal configurations, which have been proven most effective in providing the necessary plasma parameters, and involves developing the data base needed to prepare for a burning plasma experiment and to identify an optimum confinement system. The approach used is to build upon theory, modeling, and previous experimental results to extend the data base and to fabricate new devices with specific technical goals when additional information is needed to complete the data base. The primary scientific issues being addressed by this research are energy confinement, heating, plasma stability, edge physics and particle control, and current drive.

Energy confinement is a major critical issue affecting the size and cost of a fusion reactor. In a reactor, the plasma must initially be heated to a high temperature for the fusion reactions to occur, and at this high temperature, the plasma thermal energy must be sufficiently well contained that the heating power from the fusion reactions sustains the plasma. The research on this topic involves using and understanding auxiliary heating methods, such as neutral beam heating and radiofrequency (rf) wave heating, to heat a plasma to high temperatures and then using sophisticated diagnostics to characterize, understand, and reduce energy transport in a high temperature plasma. This work is carried out in close cooperation with experimental groups and theory groups in the Applied Plasma Physics subprogram.

As the temperature and density of a reacting plasma increase, the plasma pressure increases and the production of fusion power increases. Plasma stability research concerns understanding the limited range of plasma pressure which can be stably supported at a given magnetic field. The ratio of plasma pressure to the confining magnetic field pressure is referred to as beta. Since achievable magnetic fields are limited, experiments are carried out with alternate plasma shapes and operating modes predicted to reduce the required confining magnetic field. These experiments include attempts at obtaining a predicted second regime of stability at even higher beta.

The current drive issue addresses operation in a steady state mode as opposed to a pulsed mode. The primary advantage of steady state operation in a reactor is that it will reduce component fatigue problems. Planned experiments will attempt to drive continuous currents in tokamaks with radio frequency. The final technical issue is edge physics and particle control. Impurities dilute the fuel, cool the plasma, and cause it to contract and become unstable. Thus, impurities must be controlled throughout the period of operation. A major source of these impurities is particles hitting the vessel walls. Studies are being conducted to ensure that the plasma is kept as clean as possible by reducing the generation of impurities and by isolating the impurities that are generated. A related issue concerns methods of fueling to replenish the reacting ions. Current experiments are testing fueling by injection of frozen pellets. It is now recognized that edge physics and particle control can have a significant effect on the energy confinement time.

Research is being conducted on several toroidal devices to investigate the above mentioned physics issues and to prepare for performing the burning plasma physics experiments on TFTR and on CIT. The confinement of high temperature plasmas will be studied in the Tokamak Fusion Test Reactor (TFTR) device at Princeton Plasma Physics Laboratory (PPPL). Experiments on the confinement, beta, and current drive issues will be carried out on the Doublet-III-D device at General Atomics (GA). The objective of the Alcator C Modification facility at the Massachusetts Institute of Technology (MIT) is to study rf heating energy confinement, and current ramp-up in a high field, high density plasma. The former Alcator-C tokamak has been moved to Lawrence Livermore National Laboratory (LLNL) and renamed the Microwave Tokamak Experiment (MTX). This provides LLNL with the unique target plasma capability to test the application of pulsed high power microwaves as a more efficient heating technique in tokamak devices. International collaboration will be relied on to carry out research on a number of related plasma issues in foreign facilities including Textor and ASDEX in West Germany, Tore Supra in France, Joint European Torus (JET) in Europe, JIPP-T-IIU and JT-60 in Japan. The PBX device at PPPL will be put into a non-active status and will not complete its research program until the TFTR D-T program has been completed.

A concentrated U.S. analysis effort has been underway to establish the physics basis for achieving ignition and burn, using the experimental data base from these U.S. and foreign experiments. Achievement of ignition has always been an essential objective of magnetic fusion research. We have now reached the point where experimental progress justifies proceeding with an ignition experiment. The construction and successful operation of CIT would demonstrate the fundamental feasibility of magnetic fusion, provide key support to the President's initiative to conduct a joint International Thermonuclear Experimental Reactor program, and maintain the scientific progress in the U.S. fusion program. This budget continues the design and R&D effort to build such an ignition device. It is planned to be built at PPPL, using the TFTR facilities, by a national physics and engineering team. It is the essential next step in the U.S. Fusion Program and it has been incorporated into international planning.

Work on identifying an optimum toroidal confinement system will be conducted on the Advanced Toroidal Facility (ATF) at the Oak Ridge National Laboratory (ORNL). This device will explore regimes that are theoretically predicted to produce much higher betas than present tokamaks. With its external field coils, ATF will also test the feasibility of running high-beta plasmas in steady state.

Upgrades and modifications to existing devices are supported by major device fabrication (MDF) projects. These projects increase the inherent capability of the devices in a cost effective way as progress is made towards understanding the relevant physics issues. The only remaining MDF project is the C-Mod at MIT which will be completed in FY 1990.

All Mirror Fusion Test Facility-B support will end in FY 1990.

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

II. A. Summary Table

Program Activity	FY 1988	FY 1989	FY 1990	% Change
Toroidal Systems				
Tokamak Fusion Test Reactor..	$ 69,095	$ 71,035	$ 68,800	+ 3
Base Toroidal Research.......	39,418	55,456	64,400	+ 16
Advanced Toroidal Research...	28,341	25,588	13,150	- 49
Major Device Fabrication.....	11,040	4,900	3,800	- 22
Compact Ignition Tokamak.....	8,112	15,000	15,000	0
Subtotal, Toroidal Systems..	156,006	171,979	165,150	- 4
Mirror Systems................	3,599	2,775	3,000	+ 8
Total, Confinement Systems....	$159,605	$174,754	$168,150	- 4

II. B. Major Laboratory and Facility Funding

General Atomics...............	$ 30,390	$ 28,820	$ 33,525	+ 16
Lawrence Livermore Nat. Lab....	13,730	15,595	14,500	- 7
Mass. Institute of Technology..	11,635	11,700	17,330	+ 48
Oak Ridge National Laboratory..	17,330	18,690	17,645	- 6
Princeton Plasma Physics Lab...	84,077	95,898	78,950	- 18

III. Activity Descriptions

Program Activity	FY 1988	FY 1989	FY 1990
Tokamak Fusion Test Reactor	Continued experiments on high temperature plasmas at near breakeven conditions.	Use full neutral beam and Ion Cyclotron Radio Frequency (ICRF) heating power to investigate techniques for achieving breakeven equivalent and to improve understanding of confinement.	Full power neutral beams and 6MW of ICRF will be used to establish and study deuterium plasma parameters in the Q ~ 1 range. The pulse length of the ICRF heating power will be extended to the full flattop time of 2 sec. Preparation for D-T will be delayed to allow continued operation of TFTR to focus experiments on

III. Confinement Systems (Cont'd)

Program Activity	FY 1988	FY 1989	FY 1990
Tokamak Fusion Test Reactor (Cont'd)			confinement in the world's hottest tokamak. Improved diagnostics will be installed.
	Began ICRF heating experiments with 6 MW system.		
	Completed design of the shielding, external maintenance manipulator, tokamak modifications, and diagnostics needed for deuterium-tritium operation.		
Total Tokamak Fusion Test Reactor	$69,095	$71,035	$68,800
Base Toroidal	Investigated energy confinement time and beta limits in DIII-D in different plasma configurations and initiate 2 MW inside launch ECH and 2MW Ion Bernstein Wave experiments. A Japanese research team continued to participate in the DIII-D experiments through 1992.	Carry out experiments on DIII-D to gain a detailed understanding of energy confinement time and beta as functions of plasma shape, current profile, and edge plasma conditions in both diverted and limiter discharges with an emphasis on pressure and current profile control with RF, neutral beam injection, and pellets, with longer pulse discharges.	Continue energy confinement and high beta programs with optimized profile/ shape control; test moderate beta with non-inductive current drive. Initiate fast wave current drive (ICRF) experiments. Begin installation of 115GHz ECH system, fast wave ICRF system, and divertor modifications for edge and profile optimization.
	Continued work on facility preparations, diagnostic upgrades, and data acquisition systems for Alcator C-MOD.	Initiate installation of major components, diagnostic upgrades, and data acquisition systems to support initial full power operation of	Finish installation of the major components, diagnostics, data acquisition systems, and control systems of Alcator C-MOD. Begin

Program Activity	FY 1988	FY 1989	FY 1990
Base Toroidal (Cont'd)		Alcator C-MOD in 1990. Continue development of advanced diagnostics, ECH, and advanced operating modes for C-MOD.	operation in mid-1990 by conducting ohmic experiments to explore basic plasma operation of a high field, shaped, and diverted tokamak; and begin initial pellet fueling experiments. Continue development of advanced diagnostics, and advanced toroidal modes of operation for C-MOD.
	The MTX major device fabrication (MDF) was completed. Work on transfer of pulsed Free Electron Laser (FEL) microwave power continued.	MTX will begin operation, first with ohmic only plasmas and then with ohmic plus a single, high power, 140 GHz FEL pulse. Preparations for the 250 GHz pulses will continue and the Japanese will collaborate on MTX by providing diagnostics.	MTX will begin injecting single high power, 250 GHz FEL pulses into ohmic plasmas at full magnetic field.
	Under collaborative programs with the several European countries, the DOE (1) continued the edge physics and particle control experiments on TEXTOR jointly with West Germany and Japan, (2) completed hardware fabrication and particle control and began pellet fueling, and ICRF heating experiments on Tore Supra, (3) completed the first phase of pellet fueling experiments on JET, and (4) continued a collaborative research program on poloidal divertor and confinement experiments on ASDEX.	Using international collaboration, continue joint experiments on fueling, edge physics and particle control, heating, and energy confinement on TEXTOR, ASDEX, JET, and Tore Supra, and JIPP-T-IIU; Begin LH current drive experiments in ASDEX.	Continue collaborative experiments on edge physics, particle control, fueling, heating, current drive, and confinement experiments on TEXTOR, ASDEX, JET, and Tore Supra; complete experiments on JIPP-T-IIU.

Program Activity	FY 1988	FY 1989	FY 1990
Base Toroidal (Cont'd)			Support is provided for innovative proposals that would improve our understanding of controlling tokamak confinement.
Total Base Toroidal	$39,418	$55,456	$64,400
Advanced Toroidal	Diagnostics required for physics experiments for Advanced Toroidal Facility (ATF) was installed. A preliminary assessment of the performance of the ATF device was made. Initial studies of energy confinement, high-beta, impurity control, and heating with 2MW neutral beams were undertaken.	Investigation of high beta (second stability regime), transport, and plasma material interactions and particle control will continue. Pellet fueling studies, an assessment of different methods of impurity control on ATF, and stellarator configuration studies will also be made.	Optimize device performance, using existing hardware. Continue low collisionality transport, beta limits and second stability studies on a half-time basis.
	Experiments on optimization of confinement and beta limits on PBX were begun.	PBX-M will begin using ion bernstein wave (IBW) heating and lower hybrid (LH) current drive in their efforts to increase beta.	The PBX-M experimental program will be mothballed until after the completion of DT in TFTR.
Total Advanced Toroidal	$28,341	$25,588	$13,150
Major Device Fabrication	Site preparation and device fabrication for Alcator C-MOD at MIT were continued.	Finish fabrication and begin installation of Alcator C-MOD at MIT in preparation of full power operation in 1990 with 4MW of ICRF heating.	Installation of Alcator C-MOD at MIT is finished, and operation of a flexible, high performance tokamak begins in mid-1990. 4MW of ICRF heating will be installed for operation in late 1990.

Program Activity	FY 1988	FY 1989	FY 1990
Major Device Fabrication (Cont'd)	Completed the MTX fabrication.		
Total Major Device Fabrication	$11,040	$4,900	$3,800
Compact Ignition Tokamak	Completed CIT conceptual design. Continued technology R&D tasks in support of preliminary design. Continued NEPA environmental review.	Continue CIT project R&D. Initiate prototype fabrication of CIT TF and PF coils and a vacuum vessel segment.	Continue CIT project R&D. Complete fabrication and testing of CIT prototypes of TF and PF coils and vacuum vessel segment.
Total Compact Ignition Tokamak	$8,112	$15,000	$15,000
Tandem Mirror Operations	Continued close-out of contracts, and maintained MFTF-B in a mothballed state.	Continue close-out of MFTF-B contracts and maintain the system components for other uses in a safe and secure way.	The mirror program will be completed with the final close-out of MFTF-B.
Total Tandem Mirror Operations	$3,599	$2,775	$3,000
Total Confinement Systems	$159,605	$174,754	$168,150

I. Preface: Applied Plasma Physics

The Applied Plasma Physics subprogram also has a major role in addressing the magnetic confinement and burning plasma issues. Applied Plasma Physics conducts research on basic magnetic confinement physics, including non-tokamak configurations and supports and supplements research performed in the Confinement Systems subprogram by developing information on new techniques for diagnostics and for plasma heating and control and by developing basic data necessary to design and conduct larger scale fusion experiments. Activities include: theoretical and experimental physics support, research on advanced fusion concepts, and large-scale computing capability.

In Advanced Fusion Concepts, the scientific understanding of magnetically confined plasmas is being pursued through experiments with varying magnetic configurations. Configurations currently being evaluated are categorized by the names Reversed Field Pinch (RFPs), Field Reversed Configurations

(FRCs), and Spheromaks. These configurations offer particular technological advantages in reactor embodiments. They all offer high beta plasmas, that is, high power density within the plasma and consequent efficient use of the applied magnetic fields. RFP's should not require auxiliary heating. FRC's and spheromaks have simple magnet systems but different stability properties. Each of these configurations provide a different physical environment in which magnetically confined plasma obeys the same overall physical laws governing plasma stability and transport of energy and particles within the plasma. Thus the study of these different configurations provides unique insights valuable to the understanding and mathematical approximation of physical laws governing the behavior of magnetically confined plasma. Design of an RFP, the first configuration to be tested in the CPRF, is also underway. During FY 1990 these configurations will be studied through the following research: an operation of an RFP device at U. of Wisconsin, completion and first operation of an FRC device at Spectra Technology with supporting work at U. of Washington and Spheromak research at U. of Maryland. Continuation of the Confinement Physics Research Facility is supported under the Construction account.

Plasma processes that determine the success of magnetic confinement are complex. The Fusion Plasma Theory and Experimental Plasma Research branches supply basic tools for understanding these plasma processes and in FY 1990 emphasis will be given to applying these tools to current tokamaks. Also, new ideas for plasma heating or control will be given small scale tests.

Theory supports development of models and mathematical techniques to describe and predict the behavior of magnetically confined plasma. In FY 1990 specific emphasis will be given to fundamental predictions and modelling of processes controlling transport of energy and particles in toroidal plasma. Activities will also include modelling to predict and interpret plasma heating by ion cylotron waves (ICRF), electron cyclotron waves (ECH) and fast alpha particles generated within the fusion reaction. In addition, general models are developed to extract physics features common to different confinement geometries and to develop predictive capability for parameter ranges not yet explored. This work uses both analytical and numerical techniques and is located at universities, national laboratories and industrial contractors.

The Experimental Plasma Research activity provides experimental techniques, basic data, and fundamental physics information required to operate and interpret present major confinement experiments. In FY 1990, at selected tokamaks, diagnostics will be installed and applied that can measure properties associated with energy and particle transport. Also, new diagnostic techniques required for measuring plasma properties will be developed and tested. Atomic data necessary for understanding plasma behavior will be obtained and compiled. New ideas currently receiving first tests are directed to improved heating and current drive, better particle and energy control and plasma stability at higher betas. Most of this work is at universities, with some activities at national laboratories and industry as well.

The Energy Sciences computing network provides access to state-of-the-art computational hardware (CRAY 1 and CRAY 2 computers). The network facilities provide support for the development of models and codes of plasma theory, for management and interpretation of experimental results, and for design of large scale fusion experiments. The network consists of the computers at LLNL and five user service centers at LLNL, LANL, General Atomic, PPPL, and ORNL, together with international data links and telephone line access by smaller users.

The following table summarizes the operating funding for the Applied Plasma Physics subprogram.

II. A. Summary Table

Program Activity	FY 1988	FY 1989	FY 1990	% Change
Advanced Fusion Concepts				
Research Operations..........	$ 10,134	$ 10,200	$ 9,975	- 2
Major Device Fabrication.....	11,312	11,290	2,120	- 81
Supporting Studies...........	688	670	855	+ 28
Subtotal, Advanced Fusion Concepts..................	22,134	22,160	12,950	- 42
Fusion Plasma Theory...........	18,582	19,590	21,000	+ 7
Experimental Plasma Research...	16,015	18,175	23,480	+ 29
National MFE Computer Network..	18,044	18,230	15,785	- 13
Total, Applied Plasma Physics.	74,775	78,155	73,215	- 6

II. B. Major Laboratory and Facility Funding

University of California at Los Angeles..................	$ 2,625	$ 2,542	$ 2,680	+ 5
General Atomics................	2,424	2,600	2,550	- 2
Lawrence Livermore Nat. Lab....	18,485	18,275	16,250	- 11
Los Alamos National Laboratory.	16,934	16,070	7,785	- 52
Mass. Institute of Technology..	3,622	2,690	2,700	0
Oak Ridge National Laboratory..	4,017	3,890	3,790	- 3
Princeton Plasma Physics Lab...	3,839	3,300	3,255	- 1
Spectra Technology.............	4,010	3,875	3,020	- 22
University of Texas............	5,430	6,225	6,275	+ 1
University of Wisconsin........	3,969	3,920	4,375	+ 12

III. Activity Descriptions

Program Activity	FY 1988	FY 1989	FY 1990
Advanced Fusion Concepts	Continued work on CPRF MDF project as proposed in FY 1988 while reviewing the project scope and schedule.	Continue the CPRF MDF project.	Continuation of the CPRF MDF project is supported under the Construction account.
	Continued LSX MDF project at Spectra Technologies.	Delay LSX MDF project by 8 months.	Complete LSX MDF during third quarter.
	Incorporated minor upgrades and continued studies in small reversed field pinch (RFP) and compact toroid devices. The Spheromak device terminated operation at PPPL.	Modify Maryland Spheromak to increase temperature as part of the energy confinement study. Continue heating of LANL FRC device, and study transport. Use ZT-40 program at LANL to prepare for RFP experiments in the Confinement Physics Research Facility (CPRF). Continue studies on University of Wisconsin RFP device.	Continue Maryland Spheromak and FRC (LANL) heating experiments. Study RFP boundary physics at Wisconsin. Discontinue RFX-C at LANL and redirect effort to development of diagnostics for new RFP. Prepare for operation of LSX.
Total Advanced Fusion Concepts	$22,134	$22,160	$12,950
Fusion Plasma Theory	Continued to apply theory to understand plasma confinement experiments.	Continue to apply theory to understand plasma confinement experiments.	Continue to emphasize theory that seeks understanding of transport processes controlling plasma confinement.
	Expanded research in the theory of burning plasma.	Continue theory on ignition physics, both by providing increased theory support for confinement experiments that are directly related to CIT and by developing new codes and models. Expand efforts in alpha-particle theory and studies of transport and support for diagnostics in these areas.	Continue theory related to CIT with emphasis on plasma heating by RF waves (ICRF and ECH) and by fast alphas generated within reacting plasma.

Program Activity	FY 1988	FY 1989	FY 1990
Fusion Plasma Theory (Cont'd)	Continued to carry out theoretical analysis of alternate concept experiments.	Continue to carry out theoretical analysis of alternate concept experiments.	Provide predictions of behavior for new FRC plasmas and refine RFP theory to support Wisconsin experiment and future RFP device at LANL.
Total Fusion Plasma Theory	$18,582	$19,590	$21,000
Experimental Plasma Research	Continued innovative experiments on current drive and high frequency RF effects in plasma. Planned for testing these ideas on larger devices.	Conduct tests of current drive on larger devices. Continue basic experiments on high frequency RF effects in plasma.	Evaluate experiments on helicity injection current drive. Develop concepts for current profile control in tokamaks.
	Developed concepts for plasma stabilization that have promise for leading to new regimes of tokamak operation.	Operating time and heating capability are increased to extend results of earlier experiments to higher temperature plasmas. Initiate some tests of the plasma stabilization concepts developed in FY 1988. Construct new coils and vacuum chamber for TEXT to study edge configuration effects on transport.	Install new coils, vacuum chamber, additional diagnostics, and additional ECH power at TEXT and initiate transport studies with various edge configurations.
	Construction of diagnostic devices to be tested for application to alpha particle confinement on CIT was begun.	Construct and test alpha diagnostic devices. Install and apply diagnostic devices to measure transport-related properties at major tokamaks. Test alpha diagnostic approaches.	
	Continued basic physics studies in atomic physics, rf plasma wave coupling, and energy or particle transport within plasma that will improve plasma modeling.	Conduct basic physics experiments with emphasis on plasma wave coupling to assist design of RF heating for major experiments.	Continue basic physics studies in electron-ion atomic physics and plasma-wave interactions.

III. Applied Plasma Physics (Cont'd)

Program Activity	FY 1988	FY 1989	FY 1990
Experimental Plasma Research (Cont'd)	Selected and compiled atomic data for fusion applications.	Begin publication of recommended atomic data for fusion in international collaboration through IAEA.	Compile and recommend atomic data for application to plasma edge issues with IAEA.
Total Experimental Plasma Research	$16,015	$18,175	$23,480
MFE Computer Network	Provided access to supercomputers for fusion researchers via a satellite network with two CRAY 1 and one CRAY 2 computers at National Magnetic Fusion Energy Computer Center at LLNL. Coordinated program with Energy Sciences Advanced Computation. Continued upgrades of central file storage and network structure to adequately support users.	Continue supporting large-scale computing and data analysis for the fusion program, through operation of the MFE network. Provide funds to initiate an upgrade of the User Service Center at General Atomics to improve support of DIII-D experiment.	Participate with Energy Sciences Advanced Computation in operation of MFE Computer Center which operates two Cray 2's and one Cray XM-P 22 as well as the nationwide ESNET computer network, providing access to supercomputers and facilities at fusion laboratories. In addition, this activity provides partial support for local computing at major fusion sites.
Total MFE Computer Network	$18,044	$18,230	$15,785
Total Applied Plasma Physics	$74,775	$78,155	$73,215

I. Preface: Development and Technology

The Development and Technology subprogram provides for the development of the technologies needed for present and future fusion experiments and for design and analysis of fusion systems. The work is divided into three main areas: Plasma Technologies, Fusion Technologies, and Fusion Systems Analysis.

Plasma Technologies covers the development of those technologies that are needed to form, contain, heat and sustain a reacting fusion plasma. These technologies include magnetic systems, plasma heating systems, and plasma fueling systems. The principal activity in magnetic systems is to develop reliable superconducting magnets that are necessary to provide the magnetic field conditions required to confine the deuterium and tritium plasma. The heating program focuses on the technologies required to heat the plasma ions and electrons to reactive conditions and encompasses several electromagnetic wave heating approaches including electron cyclotron heating (ECH) and ion cyclotron resonance frequency (ICRF) techniques. The plasma fueling systems efforts develop high speed deuterium and tritium pellet injectors to maintain the proper amount of plasma fuel. Use of the developed heating and fueling systems has enabled the production of record plasma conditions in fusion devices and this U.S. technology is in much demand internationally. Projected experiments in higher density and higher temperature plasmas will necessitate continued development of higher power, longer pulse length, and higher frequency electromagnetic wave sources, transmission components, and improved fueling devices.

Fusion Technologies covers issues that are concerned with the systems in contact with the plasma and the effects of neutrons produced by the plasma. The goal of this area of research is to provide the information necessary to establish that magnetic fusion is a viable energy source with publicly acceptable environmental and safety characteristics. This program element includes development of heat extraction/blanket components, nuclear analysis methods, tritium production, tritium processing and control systems, materials, and environment and safety issues. The materials program element is developing reduced activation materials that will reduce the need for long term waste disposal and limit the degradation due to the bombardment of neutrons inside the fusion reactor as well as materials that are capable of functioning as first wall materials. Technologies needed for various blanket concepts are being investigated to perform their multiple functions of heat extraction, tritium production, and radiation shielding in a manner consistent with minimum environmental impact and maximum safety. Activities in tritium processing and control systems will address the requirements for reliably processing, containing, and cleaning of tritium generated in blankets. Fundamental environment and safety issues are studied to develop an understanding of potential environmental and safety concerns in a fusion system.

Fusion Systems Analysis conducts studies to define parameters of major fusion experiments and performance of possible fusion power systems. These studies help the program determine technical feasibility and costs, determine needs and objectives for R&D, and assess safety, environmental, and economic performance of future reactor concepts. A large portion of this effort will be dedicated to carry out the Presidential initiative for design of an International Thermonuclear Experimental Reactor (ITER). This will be a three year design study to determine the parameters and cost of an ITER. The goal of an ITER will be to complete the scientific database for a magnetic fusion reactor and to gain experience with technologies required to utilize fusion energy for electric power generation. A study of Advanced Tokamak Electric Power Systems will be conducted in parallel to the ITER work to better understand how ITER type devices could lead to commerical reactors with optimized safety, environmental, and economic characteristics.

Some of the significant facilities utilized in the Development and Technology subprogram include the High Field Magnet Test Facility at the Lawrence Livermore National Laboratory (LLNL) for testing of superconducting magnets; the Plasma Materials Test Facility at Sandia National Laboratories; and the RF Test Facility at ORNL. The Tritium Systems Test Assembly (TSTA) at Los Alamos National Laboratory and the fusion material, work in HFIR at ORNL and in the FFTF at Richland are also supported under collaborative agreements with Japan.

The following table summarizes the operating expense funding for the Development and Technology subprogram.

II. A. Summary Table

Program Activity	FY 1988	FY 1989	FY 1990	% Change
Magnetic Systems...........	$ 8,730	$ 7,185	$ 6,300	- 12
Heating and Fueling........	14,692	12,026	15,000	+ 25
Subtotal, Plasma Technologies	23,422	19,211	21,300	+ 11
Fusion Nuclear Technology..	6,355	6,510	6,260	- 4
Environment and Safety.....	1,636	2,100	2,140	+ 2
Fusion Materials...........	13,742	15,440	13,500	- 13
Subtotal, Fusion Technologies	21,733	24,050	21,900	- 9
Fusion Systems Analysis......	10,760	10,884	13,500	+ 24
Total, Development and Technology................	$ 55,915	$ 54,145	$ 56,700	+ 5

II. B. Major Laboratory and Facility Funding

Argonne National Laboratory....	$ 4,350	$ 4,645	$ 3,655	- 21
University of California at Los Angeles..................	2,985	3,140	2,780	- 11
Lawrence Livermore Nat. Lab....	10,434	9,650	13,130	+ 36
Los Alamos National Laboratory.	2,977	2,780	2,700	- 3
Oak Ridge National Laboratory..	16,639	12,290	10,815	- 12
Pacific Northwest Laboratory...	2,620	3,635	3,585	- 1
Sandia National Laboratories...	4,182	4,340	3,950	- 9

III. Activity Descriptions

Program Activity	FY 1988	FY 1989	FY 1990
Plasma Technologies	The non-U.S. magnets in the International Fusion Superconducting Magnet Test Facility at ORNL were removed, returned to the	A focused development program in high field, steady state and pulsed magnets for ITER is maintained with international cooperation. The U.S.	Superconducting high field, radiation tolerant magnets validated for ITER. U.S. demonstration poloidal coil tests completed in Japan.

Program Activity	FY 1988	FY 1989	FY 1990
Plasma Technologies (Cont'd)	international partners and the facility placed in "mothball" status pending future agreements on ITER program cooperations. Efforts on development of higher field superconductors to provide improved plasma confinement for ITER emphasized steady-state and pulsed conditions with scheduled testing of a pulsed coil in Japan in FY 1989.	demonstration poloidal coil will be tested in Japan.	
	Operation of compact ICRF launchers on TFTR were analyzed and appropriate improvements incorporated into a steady state launcher for Tore Supra and fabrication of a pre-prototype CIT/C-MOD antenna. Negative ion neutral beam and ECH source development was increased to provide important alternative means to heat and drive electrical currents in fusion plasmas.	ICRF development will be maintained to develop and test a system for C-Mod and CIT. Effort will continue to be applied to ECH and negative ion neutral beam development to access improved techniques for heating, current drive and plasma control for ITER.	High power CIT prototype ICRF antenna delivered to C-MOD for testing. FMIT power unit development modifications completed for CIT. Increased emphasis on ECH source development program continued for both FEL and gyrotrons.
	Testing of a tritium pellet injector at TSTA was completed and results incorporated into tritium injectors for TFTR and CIT.	Development efforts on higher performance pellet injectors is emphasized because of the need to fuel higher temperature and higher density plasmas in CIT and ITER.	Higher speed pellet injector approaches assessed and narrowed to one or two.
Total Plasma Technologies	$23,422	$19,211	$21,300

Program Activity	FY 1988	FY 1989	FY 1990
Fusion Technologies	Continued joint tritium operation at TSTA and research programs on environment, safety and blanket technology.	Continue joint operation of TSTA. In support of ITER conduct research on tritium recycling technology, on safety/ environmental issues and on experimental blanket modules for testing in ITER.	Continue joint operation of TSTA with Japan on advanced fuel clean up system. In support of ITER conduct research on tritium recycling technology, on safety/environmental issues and on experimental blanket modules for testing in ITER.
	Program for plasma interactive materials research in support of TFTR, CIT and ITER was enhanced. Studies on non-electric applications of fusion energy was completed. Increased efforts on model and code development to design and predict the performance of nuclear components.	In support of long-term fusion development, conduct research on reduced activation materials and reactor-relevant blanket technologies and perform studies of high-energy neutron sources for materials irradiation testing. In support of TFTR, CIT, and ITER, conduct research on device specific issues associated with tritium systems, plasma interactive materials and neutron effects.	Continue research on reduced activation materials and reactor-relevant blanket technologies. In support of TFTR, CIT, and ITER, conduct research on device specific issues associated with tritium systems, plasma interactive materials and neutron effects.
	Began preparation of test assembly for materials irradiation testing in the FFTF.	Begin initial materials irradiation in FFTF.	Continue material's irradiations in FFTF/MOTA.
Total Fusion Technologies	$21,733	$24,050	$21,900
Fusion Systems Analysis	Design effort on the International Thermonuclear Experimental Reactor (ITER) in cooperation with Japan, USSR, and the European community was initiated. Also initiated Advanced Reactor Innovations Evaluation Study	Maintain the ITER effort with expected completion at the end of FY 1990. Maintain the ARIES effort with completion at the end of FY 1990.	Complete ITER conceptual design study. Continue the ARIES effort as planned with effort planned for completion at the end of 1990. Initiate study of heavy ion and gas laser based reactors to provide a

III. Development and Technology (Cont'd)

Program Activity	FY 1988	FY 1989	FY 1990
Fusion Systems Analysis (Cont'd)	(ARIES) to explore several possible "visions" of fusion reactors. Completed RFP study.		current assessment of the prospects for these technologies.
Total Fusion Systems Analysis	$10,760	$10,884	$13,500
Total Development and Technology	$55,915	$54,145	$56,700

I. Preface: Planning and Projects

II. A. Summary Table

Program Activity	FY 1988	FY 1989	FY 1990	% Change
Planning and Projects........	$ 869	$ 5,000	$ 4,900	- 2
	$ 869	$ 5,000	$ 4,900	- 2

III. Activity Descriptions

Program Activity	FY 1988	FY 1989	FY 1990
Planning and Projects	Continued support of the Small Business Innovative Research (SBIR) program; continued support for inventories at ORNL.	Continue the program's legal obligation to support the SBIR program; continue support for non-fusion landlord responsibilities.	Continue the program's legal obligation to support the SBIR program; continue support for non-fusion landlord responsibilities.
Total Planning and Projects	$ 869	$5,000	$4,900

I. Preface: Program Direction

This subprogram provides the Federal staffing resources and associated funding needed to plan, direct, manage, and administer the highly scientific and technical research and development program in fusion energy.

II. A. Summary Table

Program Activity	FY 1988	FY 1989	FY 1990	% Change
Program Direction............	$ 4,600	$ 4,600	$ 5,000	+ 9

III. Activity Descriptions

Program Activity	FY 1988	FY 1989	FY 1990
Salaries and Expenses	Provided funds for salaries, benefits, and travel for 62 full-time equivalents (FTE's) in the Office of Fusion Energy and related program and management support staff. Staff activities include: 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 implementation of university and industrial research programs; oversight of construction and operation of scientific R&D facilities; control of interagency and international liaison and negotiation; and related program and management support activities. The staff continued to focus on the program management and key technical issues required for the Compact Ignition Tokamak Project and extensive use of international	Provide funds for salaries, benefits, and travel related to continuation of 62 FTE's including normal increased salary and benefits costs. Program management will continue to focus on the project management and scientific issues associated with CIT and ITER, including compliance with safety and environmental standards, and on international negotiations required for ITER. CIT activities will expand from primarily design to include R&D prototypes for several critical components. ITER activities will shift from defining the design point to conducting the conceptual design, and R&D will become more focused. This staff will also provide for continued management attention to key technical issues and international involvement required for cost-effective development of fusion energy. ($4,440)	Provide funds for salaries, benefits, and travel related to continuation of 62 FTE's. The increased funding will provide for normal increased personnel costs resulting, for example, from within-grade and merit increases. Increased programmatic effort will be required for effective management of the CIT project and increasingly heavy workload related to international negotiations and involvement in ITER activities. ITER will be in full swing, aiming for design completion by December 1990. Staff will continue to support the theory program for both CIT and ITER and the advanced fusion concepts program to begin planning for operation of the CPRF project, which is scheduled to begin operation in FY 1993. ($4,679)

III. Program Direction (Cont'd)

Program Activity	FY 1988	FY 1989	FY 1990
Salaries and Expenses (Cont'd)	collaboration to advance the program in a timely way, especially through joint projects, such as R&D and design for the ITER. ($3,944)		
Other	Provided funds for a variety of program support services such as printing and editing, supplies, and materials. Also included contractual support such as that required by the SBIR program and timesharing on various information systems and communications networks. ($656)	Continue the variety of program support required in FY 1988. ($160)	Continue the variety of program support required in FY 1988 and FY 1989. Increased funding will provide for support costs of Automated Office Support Systems workstations including hotline support, hardware modifications, upgrades, moves and telecommunications/network support. ($321)
Total Program Direction	$4,600	$ 4,600	$5,000

I. Preface: Capital Equipment

The capital equipment request for FY 1990 of $13,185,000 supports the procurement of essential hardware to facilitate the conduct of the experimental program. This permits the effective utilization of devices and people. Listed below is a summary of the specific capital equipment needs by program area.

II. A. Summary Table

Program Activity	FY 1988	FY 1989	FY 1990	% Change
Confinement Systems..........	$ 9,125	$ 11,235	$ 6,600	- 41
Applied Plasma Physics.......	3,260	2,445	485	- 80
Development and Technology...	2,480	4,155	2,300	- 45
Planning and Projects........	3,820	3,800	3,800	0
Total.....................	$ 18,685	$ 21,635	$ 13,185	- 39

III. Activity Descriptions

Program Activity	FY 1988	FY 1989	FY 1990
Confinement Systems	Purchased high power rectifiers and components for heating systems for ATF, C-MOD, and DIII-D, continued support of ongoing requirements such as vacuum equipment, analog to digital convertors and memory units for data acquisition systems, diagnostics hardware, and cryogenic systems for ATF, DIII-D, MTX, PBX, and Alcator C-MOD. Completed fabrication and testing of the maintenance manipulator in TFTR, and continued purchase of computer hardware, vacuum pumps, and diagnostics equipment for TFTR.	Continue maintenance and modest upgrades to data acquisition systems by replacing/upgrading output devices, analog to digital convertors, mass storage systems, etc., as needed. Purchase necessary power supplies, oscilloscopes, vacuum hardware, spectrum analyzers, amplifiers, detectors, RF test equipment, and safety equipment to carry out experimental programs on D-III-D, ATF, PBX, MTX, and TFTR. Initiate purchase of main thyristor power supplies for Alcator C-MOD.	Continue maintenance and modest upgrades to data acquisition systems by replacing/upgrading output devices, analog to digital convertors, mass storage systems, etc., as needed. Purchase necessary power supplies, oscilloscopes, vacuum hardware, spectrum analyzers, amplifiers, detectors, RF test equipment, and safety equipment to carry out experimental programs on D-III-D, ATF, MTX, and TFTR. Complete purchase of main thyristor power supplies for Alcator C-MOD.
Total Confinement Systems	$9,125	$11,235	$6,600
Applied Plasma Physics	Continued procurement and assembly of power handling system for CPRF project. Provided general laboratory equipment for experimental research programs at national laboratories and computing equipment for User Service Centers and NMFECC.	Continue acquisition of power system for CPRF. Provide general laboratory equipment for experimental research at national laboratories including plasma control and diagnostic equipment and equipment for alpha diagnostic devices.	Provide general laboratory equipment for experimental research at national laboratories including plasma control and diagnostic equipment and equipment for alpha diagnostic devices.
Total Applied Plasma Physics	$3,260	$2,445	$ 485
Development and Technology	Special and general purpose equipment was purchased to increase the efficiency and productivity of the research and development efforts.	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.
Total Development and Technology	$2,480	$4,155	$2,300

III. Capital Equipment (Cont'd)

Program Activity	FY 1988	FY 1989	FY 1990
Planning and Projects	Purchased general purpose equipment to support non-fusion-specific landlord responsibilities at ORNL.	Purchase general purpose equipment to support non-fusion-specific landlord responsibilities at ORNL to replace obsolete and worn equipment and to provide new state-of-the-art equipment.	Purchase general purpose equipment to support non-fusion specific landlord responsibilities at ORNL to replace obsolete and worn equipment and to provide new state-of-the-art equipment.
Total Planning and Projects	$3,820	$3,800	$3,800
Total Capital Equipment	$18,685	$21,635	$13,185

Construction Program Activity	FY 1988	FY 1989	FY 1990
Compact Ignition Tokamak	Provided for initiation of architect engineering services.	Effort provides for continuation of detailed design of CIT device components and systems.	Proceed with detailed design of CIT tokamak systems and conventional facilities, placement of procurements for tokamak components and initiation of site preparations.
Total Compact Ignition Tokamak	$8,000	$3,500	$5,500
General Plant Projects	Supported projects to meet health, safety, and programmatic requirements and provided 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 to meet health, safety, and programmatic requirements and to provide miscellaneous modifications, additions, alterations, and non-major new construction items to meet programmatic goals.
Total General Plant Project	$8,900	$8,900	$9,300

III. Activity Descriptions

Program Activity	FY 1988	FY 1989	FY 1990
Confinement Physics Research Facility	Supported as an operating expense funded project.	Supported as an operating expense funded project.	Proceed with fabrication of the coils and vessel/shell.
Total Confinement Physics Research Facility	$ 0	$ 0	$13,300
Total Construction	$16,900	$12,400	$28,100

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KEY ACTIVITY SUMMARY

CONSTRUCTION PROJECTS

Magnetic Fusion Energy

IV. A. Construction Project Summary

Project No.	Project Title	Total Prior Year Obligations	FY 1989 Appropriated	FY 1990 Request	Remaining Balance	TEC
Pace Funded						
89-R-800	Confinement Physics Research Facility	30,854[a/]	10,730[a/]	13,300	20,716	75,600
GP-E-900	General Plant Projects	0	0	9,300	0	9,300
88-R-92	Compact Ignition Tokamak	$ 8,000	$ 3,500	$ 5,500	$ 438,000	$ 455,000
88-R-901	General Plant Projects	0	8,900	0	0	8,900
Subtotal, MFE Pace Construction		$ 38,854	$ 23,130	$ 28,100	$ 458,716	
Operating Funded						
-	Field Reversed Configuration	5,220	2,400	2,120	0	9,740
-	Alcator C Modification	8,900	4,900	3,800	0	17,600
Subtotal, OE Funded		$ 14,120	$ 7,300	$ 5,920	$ 0	
Total, MFE		$ 52,974	$ 30,430	$ 34,020	$ 458,716	

a/ CPRF proposed as a line item construction project in FY 1990. This project was authorized and appropriated as an operating expense funded project through FY 1989.

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KEY ACTIVITY CONSTRUCTION PROJECT SUMMARY

Magnetic Fusion Energy

IV. C. Plant Funded Construction Project

1. Project title and location: 89-R-800 Confinement Physics Research Facility
Los Alamos National Laboratory

Project TEC: $75,600
Start Date: 1st Qtr. FY 1986
Completion Date: 2nd Qtr. FY 1993

2. Financial schedule:
(Budget Authority)

Fiscal Year	Authorized	Appropriated	Obligations	Costs
1986	$ 7,711	$ 7,711	$ 7,711	$ 3,599
1987	11,850	11,850	11,850	7,692
1988	11,293	11,293	11,293	13,812
1989	10,730	10,730	10,730	14,577
1990	34,016	13,300	13,300	15,204
1991		10,660	10,660	9,050
1992		8,564	8,564	9,224
1993		1,492	1,492	2,442

3. Narrative:

(a) The presently operating reversed field pinch (RFP) devices have achieved outstanding experimental results which surpass design specifications for the devices. It is now important to extend the plasma current capability in order to test energy confinement. As a result, a device will be fabricated which will have a 1.7 MA capability. This will bring to the fusion program an experimental capability to explore, in a multikilovolt collisionless regime, the physics properties of a toroidal confinement concept that has the theoretical potential, in a future device, of ohmic heating to ignition with low magnetic fields at the magnet coils.

(b) The CPRF includes an existing test cell and space in an adjacent building and will consist of magnetic field coils, vaccum system, control system, structural support, and power supply system.

(c) Certain key features of the CPRF will be sized with an ultimate capability of 4 MA, thereby facilitating a cost effective upgrade to the 4 MA operating level in the future, if warranted.

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KEY ACTIVITY CONSTRUCTION PROJECT SUMMARY

Magnetic Fusion Energy

IV. B. Plant Funded Construction Project

1. Project title and location: GP-E-900 General Plant Projects
Various locations

Project TEC: $ 9,300
Start Date: 1st Qtr. FY 1990
Completion Date: 4th Qtr. FY 1991

2. Financial schedule:

Fiscal Year	Appropriated	Obligations	Costs
1990	$ 9,300	$ 9,300	$ 2,976
After 1989	0	0	6,324

3. Narrative:

(a) 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 1990 by laboratory is as follows:

Los Alamos National Laboratory	$ 500,000
Princeton Plasma Physics Laboratory	1,800,000
Oak Ridge National Laboratory	7,000,000
	$ 9,300,000

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KEY ACTIVITY CONSTRUCTION PROJECT SUMMARY

Magnetic Fusion Energy

IV. B. Plant Funded Construction Project

1. Project title and location: 88-R-92 Compact Ignition Tokamak
Princeton Plasma Physics Laboratory

Project TEC: 455,000*
Start Date: 4th Qtr. FY 1989
Completion Date: 4th Qtr. FY 1996*

2. Financial schedule:

Fiscal Year	Authorization	Appropriated	Obligations	Costs
1988	$ 8,000	$ 8,000	$ 8,000	$ 7,374
1989	3,500	3,500	3,500	3,500
1990	443,500	5,500	5,500	5,500
1991		49,000	49,000	49,000
1992		80,000	80,000	75,000
1993		84,000	84,000	79,000
1994		87,000	87,000	87,000
1995		80,000	80,000	80,000
1996		58,000	58,000	68,626

3. Narrative:

(a) This project is for design and construction of a compact, high-field, copper coil tokamak facility to generate critical, burning plasma data to allow for the successful operation of an integrated International Thermonuclear Experimental Reactor. Construction of this project will include: (1) a high magnetic field tokamak device with support structure, vacuum vessel, vacuum pumping system, liquid nitrogen cooled copper coils, and support systems and (2) a concrete test cell to accommodate the tokamak device and its support systems.

(b) The CIT experiment is necessary to bridge the gap between the operation of TFTR in the U.S. and JET in Europe and the stable equilibrium burn projected for the International Thermonuclear Experimental Reactor. The objectives for this ignition experiment are that it achieve and reveal the properties of burning plasma well before the operation of an ITER, at a relatively modest cost compared to the cost of an ITER. The CIT project provides a new test cell directly adjacent to the presently operating TFTR facility. The mission of CIT will be to realize, study, and optimize burning plasma discharges.

(c) The funding request of $5,500,000 provides for continuation of the detailed engineering design, placement of procurements for tokamak components and initiation of site preparations.

* The TEC and completion schedule have been changed to reflect the reduction in the final FY 1989 Appropriation and revisions in the FY 1990 request level for this project.

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KEY ACTIVITY CONSTRUCTION PROJECT SUMMARY

Magnetic Fusion Energy

IV. C. Operating Expense Funded Construction Project

1. Project title and location: Field Reversed Configuration
Spectra Technology

Project TEC: $9,740
Start Date: 4th Qtr. FY 1986
Completion Date: 3rd Qtr. FY 1990

2. Financial schedule:
(Budget Authority)

Prior Year	FY 1988 Actual	FY 1989 Appropriated	FY 1990 Request	To Complete
$ 2,350	$ 2,870	$ 2,400	$ 2,120	$ 0

3. Narrative:

(a) The field reversed configuration is a class of elongated toroidal plasma contained in a solenoidal magnetic field. Technical advances have made FRC's a potentially attractive confinement approach for achieving fusion power because of its high beta values.

(b) The objective of this project is to provide a device for FRC physics experiments to achieve conditions at which fusion-relevant confinement and stability can be tested. This objective is characterized by a parameter S--the average number of ion orbits between the center and edge of the plasma.

(c) The Major Device Fabrication will be completed.

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KEY ACTIVITY CONSTRUCTION PROJECT SUMMARY

Magnetic Fusion Energy

IV. C. Operating Expense Funded Construction Project

1. Project title and location: Alcator C Modification
Massachusetts Institute of Technology

Project TEC: $17,600
Start Date: 1st Qtr. FY 1987
Completion Date: 3rd Qtr. FY 1990

2. Financial schedule:
(Budget Authority)

Prior Year	FY 1988 Actual	FY 1989 Appropriated	FY 1990 Request	To Complete
$ 4,000	$ 4,900	$ 4,900	$ 3,800	$ 0

3. Narrative:

(a) The Alcator C-Mod. project will provide a unique device, using existing support facilities, to conduct a test of recent improvements in tokamak physics design of the Compact Ignition Tokamak (CIT). Alcator C Modification will allow us to develop operational techniques and control methods to produce high temperature, high density, well confined plasmas. Specific areas of physics investigation include ion cyclotron radiofrequency heating, plasma edge control, pellet fueling, impurity control, and current ramp-up.

(b) The major objective of Alcator C-Mod. is to provide unique and valuable information on transport in high density plasmas with intense ion cyclotron resonant frequency heating.

(c) Alcator C-Mod is finished and operation of the tokamak begins in mid 1990. 4MW of ICRF heating will be installed for operation.