DOE/MA-0274
Volume 2 of 4

Congressional Budget Request

Energy Supply Research and Development
Nuclear Waste Fund
Isotope Production and Distribution Fund
Basic Research User Facilities

Volume 2

FY 1989

U.S. Department of Energy
Assistant Secretary,
Management and Administration
Office of the Controller
Washington, D.C. 20585

February 1988

DEPARTMENT OF ENERGY

FISCAL YEAR 1989 CONGRESSIONAL BUDGET REQUEST

ENERGY SUPPLY RESEARCH AND DEVELOPMENT

NUCLEAR WASTE FUND

ISOTOPE PRODUCTION AND DISTRIBUTION FUND

BASIC RESEARCH USER FACILITIES

VOLUME 2

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DEPARTMENT OF ENERGY

FISCAL YEAR 1989 CONGRESSIONAL BUDGET REQUEST

SUMMARY OF ESTIMATES BY APPROPRIATIONS

BUDGET AUTHORITY IN THOUSANDS OF DOLLARS

	FY 1987 ACTUAL	FY 1988 ESTIMATE	FY 1989 REQUEST
APPROPRIATIONS BEFORE THE ENERGY AND WATER DEVELOPMENT SUBCOMMITTEES:			
ENERGY SUPPLY RESEARCH AND DEVELOPMENT..	$1,258,137	$1,860,087	$1,969,760
URANIUM ENRICHMENT......................	1,209,494	950,000	1,184,000
GENERAL SCIENCE AND RESEARCH............	326,596	355,108	364,986
ISOTOPE PRODUCTION AND DISTRIBUTION FUND	509	89	16,243
BASIC RESEARCH USER FACILITIES..........	473,206	574,945	972,613
ATOMIC ENERGY DEENSE ACTIVITIES.........	7,481,852	7,749,364	8,100,000
DEPARTMENTAL ADMINISTRATION.............	226,874	164,243	177,814
ALASKA POWER ADMINISTRATION.............	2,881	3,026	3,159
BONNEVILLE POWER ADMINISTRATION.........	432,259	165,000	136,000
SOUTHEASTERN POWER ADMINISTRATION.......	19,647	27,400	36,267
SOUTHEASTERN - CONTINUING FUND..........	3,772	---	---
SOUTHWESTERN POWER ADMINISTRATION.......	25,337	16,648	15,389
WESTERN AREA POWER ADMINISTRATION.......	238,008	249,515	298,413
WESTERN AREA POWER EMERGENCY FUND.......	225	24	---
FEDERAL ENERGY REGULATORY COMMISSION....	99,079	100,000	106,760
NUCLEAR WASTE FUND......................	499,000	360,000	448,832
GEOTHERMAL RESOURCES DEVELOPMENT FUND...	72	72	75
SUBTOTAL, APPROPRIATIONS BEFORE THE ENERGY AND WATER DEVELOPMENT SUBCOMMITTEES..........................	12,296,948	12,575,521	13,830,311

DEPARTMENT OF ENERGY

FISCAL YEAR 1989 CONGRESSIONAL BUDGET REQUEST

SUMMARY OF ESTIMATES BY APPROPRIATIONS

BUDGET AUTHORITY IN THOUSANDS OF DOLLARS

	FY 1987 ACTUAL	FY 1988 ESTIMATE	FY 1989 REQUEST
APPROPRIATIONS BEFORE THE INTERIOR AND RELATED AGENCIES SUBCOMMITTEES:			
ALTERNATIVE FUELS PRODUCTION............	437	---	---
CLEAN COAL TECHNOLOGY...................	---	50,000	525,000
FOSSIL ENERGY RESEARCH AND DEVELOPMENT..	293,171	326,975	166,992
NAVAL PETROLEUM AND OIL SHALE RESERVES..	122,177	159,663	185,071
ENERGY CONSERVATION.....................	232,362	309,517	89,359
ENERGY REGULATION.......................	23,400	21,565	20,772
EMERGENCY PREPAREDNESS..................	6,044	6,172	6,154
STRATEGIC PETROLEUM RESERVE.............	147,433	164,162	173,421
STRATEGIC PETROLEUM ACCOUNT.............	---	438,744	1,017,907
ENERGY INFORMATION ACTIVITIES...........	60,301	61,398	62,856
SUBTOTAL, INTERIOR AND RELATED AGENCIES SUBCOMMITTEES.........................	885,325	1,538,196	2,247,532
SUBTOTAL, ENERGY AND WATER DEVELOPMENT SUBCOMMITTEES.........................	12,296,948	12,575,521	13,830,311
SUBTOTAL, DEPARTMENT OF ENERGY..........	13,182,273	14,113,717	16,077,843
PERMANENT - INDEFINITE APPROPRIATIONS:			
PAYMENTS TO STATES......................	912	1,839	1,909
TOTAL, DEPARTMENT OF ENERGY.............	$13,183,185	$14,115,556	$16,079,752

DEPARTMENT OF ENERGY
FY 1989 CONGRESSIONAL STAFFING REQUEST
TOTAL WORK FORCE

	FY1987 FTE USAGE	FY1988 -FY87	FY1988 CONGR REQ	FY1989 -FY88	FY1989 CONGR REQ
ENERGY & WATER SUBCOMMITTEE					
HEADQUARTERS	4,697	264	4,961	73	5,034
FIELD	9,356	58	9,414	-75	9,339
SUBCOMMITTEE TOTAL	14,053	322	14,375	-2	14,373
INTERIOR SUBCOMMITTEE					
HEADQUARTERS	1,181	66	1,247	-111	1,136
FIELD	882	25	907	-140	767
SUBCOMMITTEE TOTAL	2,063	91	2,154	-251	1,903
GRAND TOTAL	16,116	413	16,529	-253	16,276
ADJUSTMENT		-263	-263	-209	-472
ADJUSTED TOTAL	16,116	150	16,266	-462	15,804

DEPARTMENT OF ENERGY
FY 1989 CONGRESSIONAL STAFFING REQUEST
TOTAL WORK FORCE

	FY1987 FTE USAGE	FY1988 -FY87	FY1988 CONGR REQ	FY1989 -FY88	FY1989 CONGR REQ
10:ENERGY SUPPLY RESEARCH AND DEV	922	14	936	10	946
HEADQUARTERS	644	7	651	10	661
FIELD	278	7	285	0	285
15:URANIUM ENRICHMENT	59	8	67	0	67
HEADQUARTERS	48	8	56	0	56
FIELD	11	0	11	0	11
20:GENERAL SCIENCE AND RESEARCH	42	-3	39	7	46
HEADQUARTERS	42	-3	39	7	46
25:ATOMIC ENERGY DEFENSE ACTIVITI	2,782	88	2,870	40	2,910
HEADQUARTERS	492	62	554	21	575
FIELD	2,290	26	2,316	19	2,335
30:DEPARTMENTAL ADMINISTRATION	3,333	133	3,466	6	3,472
HEADQUARTERS	1,756	79	1,835	6	1,841
FIELD	1,577	54	1,631	0	1,631
34:ALASKA POWER ADMINISTRATION	36	-1	35	0	35
FIELD	36	-1	35	0	35
36:BONNEVILLE POWER ADMIN	3,398	-18	3,380	-50	3,330
FIELD	3,398	-18	3,380	-50	3,330
38:SOUTHEASTERN POWER ADMIN	38	2	40	0	40
FIELD	38	2	40	0	40
42:SOUTHWESTERN POWER ADMIN	192	-6	186	0	186
FIELD	192	-6	186	0	186
46:WAPA - POWER MARKETING	1,160	-21	1,139	0	1,139
FIELD	1,160	-21	1,139	0	1,139
50:WAPA - COLORADO RIVER BASIN	219	21	240	0	240
FIELD	219	21	240	0	240
52:FEDERAL ENERGY REGULATORY COMM	1,562	97	1,659	0	1,659
HEADQUARTERS	1,562	97	1,659	0	1,659
54:NUCLEAR WASTE FUND	307	8	315	-15	300
HEADQUARTERS	152	14	166	29	195
FIELD	155	-6	149	-44	105
56:GEOTHERMAL RESOURCES DEV FUND	1	0	1	0	1
HEADQUARTERS	1	0	1	0	1
63:CLEAN COAL TECHNOLOGY	0	45	45	13	58
HEADQUARTERS	0	21	21	5	26
FIELD	0	24	24	8	32
65:FOSSIL ENERGY RESEARCH AND DEV	709	-6	703	-133	570
HEADQUARTERS	141	-3	138	-10	128
FIELD	568	-3	565	-123	442
70:NAVAL PETROL & OIL SHALE RES	89	6	95	0	95
HEADQUARTERS	17	5	22	0	22
FIELD	72	1	73	0	73
75:ENERGY CONSERVATION	320	32	352	-109	243
HEADQUARTERS	197	30	227	-84	143
FIELD	123	2	125	-25	100
80:EMERGENCY PREPAREDNESS	64	7	71	0	71
HEADQUARTERS	64	7	71	0	71
81:ECONOMIC REGULATION	288	-13	275	-22	253
HEADQUARTERS	288	-13	275	-22	253
85:STRATEGIC PETROLEUM RESERVE	147	0	147	0	147
HEADQUARTERS	28	-1	27	0	27
FIELD	119	1	120	0	120
90:ENERGY INFORMATION ACTIVITIES	446	20	466	0	466
HEADQUARTERS	446	20	466	0	466
94:ADVANCES FOR CO-OP WORK	2	0	2	0	2
FIELD	2	0	2	0	2
GRAND TOTAL	16,116	413	16,529	-253	16,276
ADJUSTMENT		-263	-263	-209	-472
ADJUSTED TOTAL	16,116	150	16,266	-462	15,804

[redacted]

VOLUME II

MAGNETIC FUSION

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 by the turn of the century. 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 Plan 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 Magnetic Fusion Program Plan has been accepted by the fusion community and endorsed by two recent ERAB reviews.

In this plan, the schedule for completion of magnetic fusion's development is directly related to the present technical, economic, and political uncertainties of energy supply. The Energy Security study suggests actions that could resolve these uncertainties over the next decade. However, not all of them may be resolved satisfactorily. Many obstacles separate us from the goal of the NEPP. A developed fusion energy source would provide assurance that the goals of the NEPP can be attained since it has the potential to avoid many of these obstacles. Consequently, the scientific and technological base for fusion should be essentially available by the turn of the century in order to allow a timely assessment of the role of fusion energy in the nation's energy future.

The strategy for providing this scientific and technological base is two-fold: (1) maintenance of a strong, domestic R&D program to adequately cover the necessary range of fusion science and technology, 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. These issues have been agreed to on an international level by the Economic Summit's Fusion Working Group as the focus for planning future research facilities. The U.S. program focus on these issues has also been endorsed by two recent ERAB reviews.

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. The United States is in the best technical position to proceed with such an experiment utilizing the scientific personnel and infrastructure at Princeton Plasma Physics Laboratory. As part of joint international planning to avoid duplication of costly facilities, the European Community and Japan have encouraged the United States to undertake a Compact Ignition (CIT) to provide critical information to support operation of an engineering test reactor, such as the International Thermonuclear Experimental Reactor (ITER), which is essential for completing the technical base of fusion.

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. The Princeton Plasma Physics Laboratory will complete the TFTR program in 1991. The CIT schedule should allow the facilities and personnel of this major scientific laboratory to be productively employed in addressing the important issue of burning plasma physics. A timely U.S. CIT would also provide vital information to the world program on how to operate an ITER in the ignited mode, saving several years of costly exploratory research on the reactor itself. 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 support the world fusion program.

The second key technical issue concerns magnetic confinement systems. Although significant progress continues to be made in understanding the confinement process, we do not have enough scientific knowledge at this time to design a fusion reactor that is suitable for commercial application. We must, therefore, continue to investigate several confinement systems at a modest level in order to provide this scientific knowledge. Research on this key issue is being closely coordinated internationally to maintain the broadest scientific coverage at minimum cost.

The third key issue concerns 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 well as the facilities required for testing these materials. As part of the program's international strategy, this issue is being pursued through cooperative agreements. The proposed FY 1989 budget supports the core program needed for U.S. participation in this international effort.

The fourth key issue concerns the nuclear technology of fusion systems. This issue requires advances in the basic engineering sciences, as well as the application of the results of basic fusion materials research. This issue will be completely resolved only when fuel producing blankets are integrated into other fusion systems tested in a nuclear environment, such as in an ITER. This budget supports the basic technology research that underlies the development of integrated blankets for the long-term and for the ITER design process in the near-term.

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 four years. Following discussions at the Geneva Summit, the U.S. proposed a joint effort, including the USSR as well as Japan and the EC, to develop a single conceptual design for an International Thermonuclear Experimental Reactor (ITER) by the end of 1990. After formal discussions among the four parties, the IAEA issued an inviation to the parties to participate, and the U.S. has formally accepted. We anticipate governmental decisions of the other parties in time to begin a joint design effort in March, 1988. This budget provides for continued U.S. participation in the conceptual design and validating R&D for an international ITER during FY 1989.

The FY 1988 Appropriation Act directed the Department of Energy to submit a five year plan showing how the Compact Ignition Tokamak could be built while completing the Tokamak Fusion Test Reactor program within current budgetary resources. The Department has prepared such a plan, allowing the CIT to begin operation in 1996 while completing the TFTR program as planned and maintaining a balanced but constrained base program. Our international commitments would be honored, but work aimed at issues beyond TFTR and CIT would proceed more slowly or be postponed as appropriate. This plan is illustrated in the following table.

In summary, this budget provides for a U.S. fusion program focused clearly on the key technical issues and interwoven tightly with other world fusion programs through international collaboration.

MFE OUTYEAR BUDGETS/(ESCALATED DOLLARS)
(dollars in millions)

	FY 1988	FY 1989	FY 1990	FY 1991	FY 1992	FY 1993
Compact Ignition Tokamak Total	15.5	27.0	46.0	64.0	95.0	101.0
Tokamak Fusion Test Reactor	72.1	74.3	83.0	79.0	45.0	42.0
Total Ignition	(87.6)	(101.3)	(129.0)	(143.0)	(140.0)	(143.0)
Princeton Beta Exp.	11.1	11.4	-	-	12.0	13.0
Alcator C-Mod.	10.1	15.5	16.0	16.0	17.0	17.0
Adv. Toroidal Fac.	18.1	18.0	19.0	19.0	20.0	21.0
DIII-D	29.7	32.5	33.0	35.0	46.0	48.0
Microwave Tokamak Exp.	9.3	10.5	10.0	11.0	-	-
International/Other	7.2	6.6	6.0	7.0	8.0	8.0
Mirrors	3.6	3.0	3.0	-	-	-
Conf. Systems Total	176.7	198.8	216.0	231.0	243.0	250.0
Base Dev. & Tech.	42.4	42.3	41.0	40.0	41.0	44.0
International Thermonuclear Exp. Reactor**	16.0	16.0	16.0	17.0	18.0	19.0
Dev. & Tech. Total*	58.4	58.3	57.0	57.0	59.0	63.0
Applied Plasma Physics*	78.0	80.6	79.0	80.0	82.0	87.0
General Plant Projects/ General Purpose Equip./ Program Direction	21.9	22.3	23.0	24.0	25.0	26.0
Office of Fusion Energy Total	335.0	360.0	375.0	392.0	409.0	426.0

* Basic R&D in support of the CIT program will be continued, as appropriate.
**Conceptual design report for ITER to be completed in 1990; Outyear projections include level of effort, no construction.

DEPARTMENT OF ENERGY
FY 1989 CONGRESSIONAL BUDGET REQUEST
OFFICE OF ENERGY RESEARCH
(dollars in thousands)

LEAD TABLE
Magentic Fusion Energy

Activity	FY 1987 Actual	FY 1988 Appropriation	FY 1989 Base	FY 1989 Request	Program Change Request vs Base: Dollar	Program Change Request vs Base: Percent
Operating Expenses						
Confinement Systems..........	$184,815	$158,620	$158,620	$175,565	$+ 16,945	+ 11
Applied Plasma Physics.......	75,185	74,775	74,775	78,155	+ 3,380	+ 5
Development and Technology...	50,510	55,915	55,915	54,145	- 1,770	- 3
Planning and Projects........	859	4,520	4,520	5,000	+ 480	+ 11
Program Direction............	4,000	4,600	4,600	4,600	0	0
Subtotal Operating Expenses..	315,369	298,430	298,430	317,465	+ 19,035	+ 6
Capital Equipment............	18,010	19,670	19,670	21,635	+ 1,965	+ 10
Construction.................	8,200	16,900	16,900	20,900	+ 4,000	+ 24
Total........................	341,579 a/	335,000	335,000	360,000	+ 25,000	+ 7
Operating Expenses............	(315,369)	(298,430)	(298,430)	(317,465)	+ 19,035	+ 6
Capital Equipment............	(18,010)	(19,670)	(19,670)	(21,635)	+ 1,965	+ 10
Construction.................	(8,200)	(16,900)	(16,900)	(20,900)	+ 4,000	+ 24
Staffing (FTEs)..............	61	62	62	62	0	

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

a/ Total has been reduced by $3,921,000 which has been transferred to the SBIR program.

DEPARTMENT OF ENERGY
FY 1989 CONGRESSIONAL BUDGET REQUEST
ENERGY SUPPLY RESEARCH AND DEVELOPMENT
(dollars in thousands)

SUMMARY OF CHANGES

Magnetic Fusion Energy

FY 1988 Appropriation	$ 335,000
Adjustments	0
FY 1989 Base	$ 335,000
Operating Expenses	
- The operating budget has been increased by about 6 percent. This provides for cost of living increases for most elements of the program and for project funding requirements associated with R&D support for the CIT and the fabrication of the C-Mod device while further focusing effort in the technology development area on only the most critical feasibility issues	+ 19,035
Capital Equipment	
- Funding is increased in the Toroidal Confinement Systems area and the technology area to provide the necessary hardware to support the experiments planned for FY 1989	+ 1,965
Construction	
- This increase provides for continuation of the design effort on the Compact Ignition Tokamak	+ 4,000
FY 1989 Congressional Budget Request	$ 360,000

KEY ACTIVITY SUMMARY

MAGNETIC FUSION ENERGY

I. Preface: CONFINEMENT SYSTEMS

The Confinement Systems subprogram supports 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. This work involves developing a data base needed to resolve scientific issues, preparing for a burning plasma experiment and identifying an optimum confinement system. The approach used is to build upon theory, modeling, and previous experimental results to construct the data base and to fabricate new devices with specific technical goals when additional information is needed to complete the data base. The primary technical issues being addressed by this research are energy confinement, plasma stability, heating, current drive and particle control.

Energy confinement relates to understanding plasma behavior so that plasma can be contained long enough for significant fusion reactions to occur. The plasma also must be heated to high temperatures for the fusion reaction to occur. Auxiliary heating methods, such as neutral beam heating and radiofrequency (rf) wave heating, are being evaluated experimentally in high power environments. As the temperature and density of the plasma increase, pressure increases and the output of fusion power increases. The plasma stability issue refers to the limiting 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 characterized as beta. Higher magnetic fields require larger, more costly magnets. Therefore, experiments are carried out with alternate plasma shapes and operating modes predicted to increase beta. These experiments include attempts at obtaining a predicted second regime of stability at even higher beta.

The current drive issue addresses the operation of devices in a steady state mode as opposed to a pulsed mode. The primary advantage of steady state operation is that it will reduce component fatigue problems. Planned experiments will attempt to drive continuous currents in tokamaks with rf. The final technical issue is 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. The other half of this issue is fueling to replenish the reacting ions. Current experiments are testing fueling by injection of frozen pellets.

Research is being conducted on several toroidal devices to prepare for addressing the burning plasma issue. 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 beta issue will be carried out on the Doublet-III-D device at GA Technologies. The objective of the Alcator C Modification facility at the Massachusetts Institute of Technology (MIT) is to study rf heating current drive and current ramp-up in a high field, high density plasma. The Microwave Tokamak Experiment (MTX) is being fabricated at LLNL using the old Alcator C device from MIT. This will provide LLNL with the unique 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, and JT-60 in Japan.

I. CONFINEMENT SYSTEMS (Cont'd)

A concentrated U.S. analysis effort has been underway to establish the physics bases for achieving ignition and burn, using the experimental data base from these U.S. and foreign experiments. Achievement of ignition has always been a major 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 scientific program in the U.S. fusion program. This budget continues the design and R&D effort to build such an ignition device, the Compact Ignition Tokamak (CIT), at PPPL. 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 Princeton Beta Experiment (PBX) at PPPL and the Advanced Toroidal Facility (ATF) at the Oak Ridge National Laboratory (ORNL). These devices will explore regimes that are theoretically predicted to produce much higher betas than present tokamaks. The PBX program will study the feasibility of very high beta tokamak operation.

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.

In the Mirror Systems subprogram the research effort will be terminated and MFTF-B put in stand-by status.

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

II. A. Summary Table

Program Activity	FY 1987	FY 1988	FY 1989	% Change
Toroidal Systems				
Tokamak Fusion Test Reactor..	$ 71,982	$ 68,275	$ 71,300	+ 4
Base Toroidal Research.......	40,203	40,601	54,115	+ 33
Advanced Toroidal Research...	26,967	27,595	27,250	- 1
Major Device Fabrication.....	15,694	11,040	4,900	- 56
Compact Ignition Tokamak.....	10,782	7,510	15,000	+100
Subtotal, Toroidal Systems..	165,628	155,021	172,565	+ 11
Mirror Systems................	19,187	3,599	3,000	- 17
Total, Confinement Systems....	$184,815	$158,620	$175,565	+ 11

II. B. Major Laboratory and Facility Funding

Program Activity	FY 1987	FY 1988	FY 1989	% Change
GA Technologies, Inc...........	$ 30,500	$ 28,720	$ 29,860	+ 4
Lawrence Livermore Nat. Lab....	27,568	13,440	15,000	+ 12
Mass. Institute of Technology..	18,091	11,315	14,750	+ 30
Oak Ridge National Laboratory..	21,038	17,862	21,195	+ 19
Princeton Plasma Physics Lab...	82,119	82,037	87,930	+ 7

III. Activity Descriptions

Program Activity	FY 1987	FY 1988	FY 1989
CONFINEMENT SYSTEMS			
Tokamak Fusion Test Reactor	Completed installation of 2-second pulse neutral beam sources and begin experiments designed to extend operating range to breakeven conditions in deuterium plasmas (i.e. deuterium-tritium plasma conditions that would result in a fusion power output equal to the input heating power).	Continue experiments of high temperature, high density plasmas at breakeven conditions and achieve breakeven equivalent conditions in deuterium plasmas.	Use full neutral beam and ICRF heating power to investigate techniques for achieving breakeven in deuterium- tritium plasmas.
	Began modifying existing 6 MW ion cyclotron radio frequency (ICRF) heating system for transfer from PLT to TFTR.	Begin ICRF heating experiments with 6 MW of power launched into the plasma.	Increase ICRF power from 6MW to 9MW.
	Reoriented one neutral beam line to improve beam heating performance.		

III. CONFINEMENT SYSTEMS (Cont'd)

Program Activity	FY 1987	FY 1988	FY 1989
Tokamak Fusion Test Reactor (Cont'd)	Began design and construction of the D-T systems needed for tritium operation in late 1990.	Complete the commissioning of the tritium handling systems. Complete design and begin fabrication of the shielding, external maintenance manipulator, tokamak modifications, and diagnostics needed for deuterium-tritium operation.	Complete the assessment of heating, confinement, impurity transport, and stability limits at full parameters and select the optimum method(s) for the D-T experiments. Carry out tests of the tritium handling systems using small amounts of tritium. Install many of the systems (diagnostics, shielding, and external maintenance manipulator) and begin the tokamak modifications needed to increase reliability for D-T operation in late 1990.
Total Tokamak Fusion Test Reactor	$71,982	$68,275	$71,300
Base Toroidal	In DIII-D, initial results were obtained on high beta with 10 MW neutral beam power, and the 1.4 MW ECH outside launch experiments were completed.	Investigate 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 will continue to participate in the DIII-D experiments through 1988.	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.
	Design work was completed and work begun on facility preparation and diagnostics for Alcator C-MOD, a state-of-the-art, high-field, high-density, ICRF-heated tokamak prototypical of CIT.	Continue work on facility preparations, diagnostic upgrades, and data acquisition systems for Alcator C-MOD.	Finish work on facility preparations, diagnostic upgrades, and data acquisition systems to support initial full power operation of Alcator C-MOD in 1990. Continue development of advanced diagnostics, ECH, and advanced operating modes for C-MOD. Begin development of additional 4MW of RF power.

Program Activity	FY 1987	FY 1988	FY 1989
Base Toroidal (Cont'd)	As part of the MTX fabrication, Alcator C was moved from MIT to LLNL. The primary goal for MTX is to test the use of high power, pulsed Free Electron Laser technology for microwave heating and current drive.	The MTX MDF will be completed. Work on transfer of pulsed Free Electron Laser microwave power will continue.	The microwave system will be installed on MTX for plasma experiments to be started in early FY 1990.
	Thru international agreements, initial results were obtained on European devices on impurity control (TEXTOR), pellet fueling (JET), energy confinement and RF heating (ASDEX). Fabrication of a pellet injector and impurity control hardware for use on Tore Supra will be mostly completed.	Under collaborative programs with the several European countries, the DOE will (1) continue the impurity control experiments on TEXTOR jointly with West Germany and Japan, (2) initiate impurity control and pellet fueling experiments on Tore Supra, (3) complete the first phase of pellet fueling experiments on JET, and (4) continue a collaborative research program on impurity control on ASDEX.	Using international collaboration, continue joint experiments on fueling, impurity control, heating, and energy confinement on TEXTOR, ASDEX, JET, and Tore Supra.
Total Base Toroidal	$40,203	$40,601	$54,115
Advanced Toroidal	The Advanced Toroidal Facility device fabrication was completed, the first phase diagnostics were installed, and preparation for initial plasma operation was completed.	Diagnostics required for physics experiments for ATF will be installed. A preliminary assessment of the performance of the ATF device will be made. Initial studies of energy confinement, high-beta, impurity control, and heating with 2MW neutral beams will be undertaken.	Investigation of high beta (second stability regime), transport, and plasma material interactions and particle control will continue on ATF. Pellet fueling studies and an assessment of different methods of impurity control on ATF will also be made.

III. CONFINEMENT SYSTEMS (Cont'd)

Program Activity	FY 1987	FY 1988	FY 1989
Advanced Toroidal (Cont'd)	Prepared for the initial exploration in PBX of increasing the tokamak beta using a highly indented plasma which theoretically permits high betas.	Begin experiments on optimization of confinement and beta limits on PBX.	PBX will use localized RF heating to increase the beta.
Total Advanced Toroidal	$26,967	$27,595	$27,250
Major Device Fabrication	Completed fabrication, installation and testing of the Advanced Toroidal Facility.		
	Completed installation of long pulse neutral beam sources and the upgrade of neutral beam lines for long pulse operation of DIII-D.		
	Completed modification of PBX-M at PPPL to permit greater indentation and an improved divertor configuration.		
	Began site preparations and device fabrication for Alcator C-MOD at MIT.	Continue site preparation and device fabrication for Alcator C-MOD at MIT.	Finish fabrication and begin installation of Alcator C-MOD at MIT in preparation of full power operation in 1990 with 4MW of ICRF heating.
	Began transfer of Alcator C tokamak to LLNL for use in the MTX facility.	Complete the MTX fabrication.	
Total Major Device Fabrication	$15,694	$11,040	$4,900

III. CONFINEMENT SYSTEMS (Cont'd)

Program Activity	FY 1987	FY 1988	FY 1989
Compact Ignition Tokamak	Continue CIT conceptual design and proceeded with NEPA environmental assessment of project. Continued technology development activities on magnet and vacuum vessel materials and on remote maintenance concepts.	Complete CIT conceptual design. Continue technology R&D tasks on prototype components. Continue NEPA environmental review.	Continue CIT project R&D. Complete prototype fabrication of CIT TF and PF coils and a vacuum vessel section.
Total Compact Ignition Tokamak	$10,782	$7,510	$15,000
Tandem Mirror Operations	For MFTF-B, began close-out of major contracts, completed documentation, and maintained all systems in working condition. Completed experiments on TMX-U during the first quarter of the year. Operated TARA at MIT to complete experiments on thermal barriers. Continued collaborative experiments on mirror devices in Japan. Operation of Phaedrus transferred to APP subprogram.	Continue close-out of contracts, and maintain 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.
Total Tandem Mirror Operations	$19,187	$3,599	$3,000
Total Confinement Systems	$184,815	$158,620	$175,565

I. Preface: APPLIED PLASMA PHYSICS

The Applied Plasma Physics subprogram has a major role in addressing the magnetic confinement and burning plasma issues. It provides support to and supplements research performed in the Confinement Systems subprogram by providing information on new techniques and new concepts and by developing vital basic data necessary to conduct larger scale fusion experiments. Activities include: research on advanced fusion concepts, theoretical and experimental physics support, and large-scale computing capability.

In Advanced Fusion Concepts, several potentially attractive alternate confinement concepts with varying magnetic configurations are investigated. Concepts currently being evaluated include Reversed Field Pinch (RFPs), Field Reverse Configurations (FRCs), and Spheromaks. Reversed Field Pinch devices require no auxiliary heating and offer efficient use of magnetic fields. Compact Toroids (FRCs and Spheromaks) have simple magnetic fields, make efficient use of confinement magnetic fields, and offer natural systems for impurity control. The work is aimed at addressing the critical technical issue of developing an optimum confinement concept. A new facility, the Confinement Physics Research Facility (CPRF), is being fabricated at LANL to provide a site at which advanced versions of the RFP, FRC, or Spheromak can be tested. Design of an RFP to be tested in the CPRF is also underway. The first test will be an RFP. During FY 1989 the three concepts are being developed through the following research: operating RFP devices at LANL and U. of Wisconsin, an FRC device under construction at Spectra Technology with supporting work at U. of Washington and an operating FRC device at LANL, a Spheromak research device at U. of Maryland.

Plasma processes that determine the success of magnetic confinement are complex. Understanding these processes and developing specialized plasma heating and control techniques are required for extrapolation to optimum magnetic confinement and burning plasma performance. The Fusion Plasma Theory and Experimental Plasma Research branches supply basic tools for understanding plasma phenomena and for the development of new ideas.

Theory supports development of models and mathematical techniques to describe and predict the behavior of magnetically confined plasma. General models are developed to extract physics features common to different confinement geometries and to develop predictive capability for parameter ranges not yet explored. Theories and models are developed to interpret results from confinement experiments, using both analytical and numerical techniques. This work is supported 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. Diagnostic techniques required for measuring plasma properties are developed and tested. Atomic data necessary for understanding plasma behavior are obtained. 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, GA Technologies, PPPL, and ORNL, together with telephone line access by smaller users and international data links.

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

II. A. Summary Table

Program Activity	FY 1987	FY 1988	FY 1989	% Change
Advanced Fusion Concepts				
Research Operations..........	$ 13,645	$ 10,171	$ 10,720	+ 5
Major Device Fabrication.....	9,250	11,312	13,390	+ 18
Supporting Studies...........	489	772	780	+ 1
Subtotal, Advanced Fusion Concepts..................	23,384	22,255	24,890	+ 12
Fusion Plasma Theory...........	18,112	18,635	18,800	+ 1
Experimental Plasma Research...	15,292	15,806	16,180	+ 2
National MFE Computer Network..	18,397	18,079	18,285	+ 1
Total, Applied Plasma Physics.	$ 75,185	$ 74,775	$ 78,155	+ 4

II. B. Major Laboratory and Facility Funding

University of California at Los Angeles...................	$ 2,593	$ 2,565	$ 2,400	- 6
GA Technologies, Inc...........	2,975	2,250	2,450	+ 9
Lawrence Livermore Nat. Lab....	18,437	18,481	18,660	+ 1
Los Alamos National Laboratory.	15,830	16,231	19,070	+ 17
Mass. Institute of Technology..	2,499	3,614	2,550	- 29
Oak Ridge National Laboratory..	3,989	3,966	3,825	- 3
Princeton Plasma Physics Lab...	6,354	3,821	3,410	- 11
Spectra Technology.............	3,120	4,010	3,875	- 3
University of Texas............	5,560	5,463	6,350	+ 16
University of Wisconsin........	3,501	3,692	3,960	+ 7

III. Activity Descriptions

Program Activity	FY 1987	FY 1988	FY 1989
APPLIED PLASMA PHYSICS			
Advanced Fusion Concepts	Continue fabrication of Confinement Physics Research Facility (CPRF) at LANL.	Continue work on CPRF MDF project as proposed in FY 1988 while reviewing the project to revise the scope and schedule targeted at a $52.5 million total project cost.	Continue the CPRF MDF project consistent with revisions to be made in FY 1988.
	Continue Field Reversed Configuration (FRC) construction at Spectra Technology, Seattle.	Continue FRC MDF project.	Continue, but delay, FRC MDF project by 8 months; complete MDF during 3rd quarter FY 1990.
	Study confinement, stability and heating in small scale Spheromaks, FRCs and RFPs at PPPL, LANL, GA, the University of Washington, and the University of Maryland.	Incorporate minor upgrades and continue studies. The Spheromak device will terminate 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 CPRF. Continue studies on University of Wisconsin RFP device.
Total Advanced Fusion Concepts	$23,384	$22,255	$24,890
Fusion Plasma Theory	Continue basic theoretical plasma research on transport, stability, auxiliary heating, and fueling that guides and interprets plasma development throughout the magnetic fusion program.	Continue to apply theory to understand plasma confinement experiments.	Continue to apply theory to understand plasma confinement experiments.
	Increase toroidal theory by redirection of mirror theory effort.		

Program Activity	FY 1987	FY 1988	FY 1989
Fusion Plasma Theory (Cont'd)	Initiate effort on CIT-related physics.	Expand research in the theory of burning plasma.	Continue theory on CIT-related 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. Provide additional support for the modeling of CIT-related diagnostics.
	Carry out theoretical analysis of alternate concept experiments.	Continue to carry out theoretical analysis of alternate concept experiments.	Continue to carry out theoretical analysis of alternate concept experiments.
Total Fusion Plasma Theory	$18,112	$18,635	$18,800
Experimental Plasma Research	Conduct tests of innovative current drive concepts. Initiate experiments using high frequency RF for heating, stabilization, and plasma transport studies at TEXT.	Continue innovative experiments on current drive and high frequency RF effects in plasma. Plan 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.
	Carry out basic experiments on plasma transport and high beta stability in several small plasma devices.	Develop concepts for plasma stabilization that have promise for leading to new regimes of tokamak operation.	Initiate some tests of the plasma stabilization concepts developed in FY 1988.
	Initiate tests of ideas on confined alpha diagnostics for burning plasma (CIT). Improve and test diagnostics for measurement of plasma current profiles.	Begin to construct diagnostic devices to be tested for application to alpha particle diagnostics on CIT.	Construct and test alpha diagnostic devices.

Program Activity	FY 1987	FY 1988	FY 1989
Experimental Plasma Research (Cont'd)	Advance the understanding of the role of resonances in electron-ion collisions occuring in plasma.	Continue 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 CIT.
	Select and compile atomic data for fusion applications.	Select and compile atomic data for fusion applications.	Begin publication of recommended atomic data for fusion in international collaboration through IAEA.
Total Experimental Plasma Research (Includes Phaedrus)	$15,292	$15,806	$16,180
MFE Computer Network	Provide access to supercomputers for fusion researchers via a nationwide satellite network with two CRAY 1 and one CRAY 2 computers at National Magnetic Fusion Energy Computer Center at LLNL. Coordinate program with Energy Science Computing. Began upgrades of central file storage and network structure.	Provide 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. Coordinate program with Energy Science Computering. Continue 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 GAT to improve support of DIII-D experiment.
Total MFE Computer Network	$18,397	$18,079	$18,285
Total Applied Plasma Physics	$75,185	$74,775	$78,155

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 obtain and sustain the conditions that are necessary to produce 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 the large 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 neutral particle beams and 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. 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. Activities in tritium processing and control systems will address the requirements for reliably processing, containing, and cleaning of tritium generated in blankets. 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.

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; the RF Test Facility at ORNL and the Tritium Systems Test Assembly at Los Alamos National Laboratory.

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

II. A. Summary Table

Program Activity	FY 1987	FY 1988	FY 1989	% Change
Plasma Technologies				
Magnetic Systems...........	$ 10,588	$ 8,510	$ 8,200	- 4
Heating and Fueling........	9,083	15,135	13,055	- 14
Subtotal, Plasma Technologies	19,671	23,645	21,255	- 10
Fusion Technologies				
Fusion Nuclear Technology..	5,769	6,648	6,300	- 5
Environment and Safety.....	1,501	1,736	1,930	+ 11
Fusion Materials...........	13,049	13,277	14,360	+ 8
Subtotal, Fusion Technologies	20,319	21,661	22,590	+ 4
Fusion Systems Analysis......	10,520	10,609	10,300	- 3
Total, Development and Technology................	$ 50,510	$55,915	$54,145	- 3

II. B. Major Laboratory and Facility Funding

Argonne National Laboratory....	3,518	4,305	4,335	+ 1
University of California at Los Angeles..................	2,739	2,925	2,930	0
Hanford Engineering Development Laboratory*..................	2,023	0	0	0
Lawrence Livermore Nat. Lab....	7,008	10,120	10,070	- 1
Los Alamos National Laboratory.	2,827	2,850	2,780	- 2
Oak Ridge National Laboratory..	20,644	15,815	13,120	- 17
Pacific Northwest Laboratory*..	317	2,790	3,185	+ 14
Sandia National Laboratory.....	3,280	4,122	3,625	- 12

* Due to consolidation of Hanford contractors, various R&D functions performed by HEDL have been transferred to PNL.

III. Activity Descriptions

Program Activity	FY 1987	FY 1988	FY 1989
DEVELOPMENT AND TECHNOLOGY			
Plasma Technologies	The International Large Coil task was completed.	The non-U.S. magnets in the International Fusion Superconducting Magnet Test Facility at ORNL will be removed, returned to the 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 will emphasize steady-state and pulsed conditions with scheduled testing of a pulsed coil in Japan in FY 1989.	A focused development program in high field, steady state and pulsed magnets for ITER is maintained with international cooperation. The U.S. demonstration poloidal coil will be tested in Japan.
	A high power compact launcher for ICRF heating in TFTR was completed and tested.	Operation of compact ICRF launchers on TFTR will be 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 will be 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 provide improved techniques for heating, current drive and plasma control for ITER.
	Pellet fueling injectors were provided to support major fusion experiments.	Testing of a tritium pellet injector at TSTA will be 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.
Total Plasma Technologies	$19,671	$23,645	$21,255

Program Activity	FY 1987	FY 1988	FY 1989
Fusion Technologies	Tritium operation at TSTA continued with initiation of a joint program with Japan for operation and testing. Research programs on environment, safety, and blanket technology were proposed.	Continue 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.
	Continued research on plasma interactive materials and neutron damage to structural materials. Support was provided for TFTR tritium program and for plasma interactive materials needs of confinement physics experiments and CIT. Initiated ITER support activities in nuclear technology.	Program for plasma interactive materials research in support of TFTR, CIT and ITER will be enhanced. Studies on non-electric applications of fusion energy will be completed. Increase 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.
	Rotating Target Neutron Source - II and Oak Ridge Reactor were shut down and preparation began for materials irradiation experiments in the FFTF.	Begin preparation of test assembly for materials irradiation testing in the FFTF.	Begin initial materials irradiation in FFTF.
Total Fusion Technologies	$20,319	$21,661	$22,590

III. DEVELOPMENT AND TECHNOLOGY (Cont'd)

Program Activity	FY 1987	FY 1988	FY 1989
Fusion Systems Analysis	The study of an innovative engineering test reactor that would provide the capability to conduct nuclear component testing as well as studies of power reactor plasma physics was completed.		
	Completed participation in the INTOR workshop activity.		
	Completed scoping studies of the reversed field pinch reactor.		
		Design effort on the International Thermonuclear Experimental Reactor (ITER) in cooperation with Japan, USSR, and the European community will be initiated.	Maintain the ITER effort with expected completion at the end of FY 1990.
		Studies of advanced tokamak reactor concepts will be initiated.	Continue the study of advanced tokamak reactor concepts with expected completion in mid FY 1990.
Total Fusion Systems Analysis	$10,520	$10,609	$10,300
Total Development and Technology	$50,510	$55,915	$54,145

I. Preface: PLANNING AND PROJECTS

II. A. Summary Table

Program Activity	FY 1987	FY 1988	FY 1989	% Change
Planning and Projects........	$ 859	$ 4,520	$ 5,000	+ 11
	$ 859	$ 4,520	$ 5,000	+ 11

III. Activity Descriptions

Program Activity	FY 1987	FY 1988	FY 1989
PLANNING AND PROJECTS	Continued support for inventories at ORNL.	Continue support of the Small Business Innovative Research (SBIR) program; continue support for inventories at ORNL.	Continue the program's legal obligation to support the SBIR program; continue support for non-fusion landlord responsibilities
Total Planning and Projects	$859	$4,520	$5,000

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 1987	FY 1988	FY 1989	% Change
Program Direction............	$ 4,000	$ 4,600	$ 4,600	-
	$ 4,000	$ 4,600	$ 4,600	-

III. Activity Descriptions

Program Activity	FY 1987	FY 1988	FY 1989
PROGRAM DIRECTION			
Salaries and Expenses	Provided funds for salaries, benefits, and travel for 61 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; implementation of university and industrial research programs: construction and operation of scientific R&D facilities; interagency and international liaison negotiation; and related program and management support activities. The staff continued to focus on the key technical issues and extensive use of international collaboration to advance the program in a timely way, especially through joint projects. ($3,726)	Provides funds for salaries and related costs of 62 full-time equivalents. Provides for the normal increased personnel costs such as within-grade and merit increases, impact of the 1987 pay raise, and the increased agency contribution to the Federal Employees Retirement System (FERS). Staff activities similar to FY 1987 will continue with extra effort required to focus on the program management and key technical issues required for the Compact Ignition Tokamak Project, including compliance with safety and environmental standards and for the ITER design and R&D effort. ($4,440)	Provides funds for salaries, benefits, and travel related to continuation of 62 FTE's. Provides for normal increased salary costs including impact of the FY 1988 pay raise, offset by a reduced benefits rate related to FERS. This staff will continue to provide effective program management which will focus on the project management and scientific issues associated with CIT and ITER and on international negotiations required for ITER. It also provides for continued management attention to key technical issues and international involvement required for cost-effective development of fusion energy. ($4,440)

III. PROGRAM DIRECTION (Cont'd)

Program Activity	FY 1987	FY 1988	FY 1989
Other	Provided funds for program support such as printing and editing services, purchase of supplies and materials, and contractor support for technical writing, editing, and other services. ($274)	Continues a variety of program support services similar to those required in FY 1987. Also includes timesharing on various information systems and communications networks such as electronic mail and contractual support to assist with environment, safety and health workload required by current regulations and directives. ($160)	Continues the variety and level of program support required in FY 1988. ($160)
Total, Program Direction	$ 4,000	$ 4,600	$ 4,600

I. Preface: CAPITAL EQUIPMENT

The capital equipment request for FY 1989 of $21,635,000 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 1987	FY 1988	FY 1989	% Change
Confinement Systems..........	$ 7,800	$ 10,110	$ 11,235	+ 11
Applied Plasma Physics.......	4,500	3,260	2,445	- 25
Development and Technology...	1,890	2,480	4,155	+ 67
Planning and Projects........	3,820	3,820	3,800	- 1
Total.....................	$ 18,010	$ 19,670	$ 21,635	+ 10

III. Activity Descriptions

Program Activity	FY 1987	FY 1988	FY 1989
Confinement Systems	Upgraded data acquisition computers for ATF, D-III, and TFTR to handle more data per shot. Continued support on ongoing requirements such as cryogenic systems, data acquisition hardware, diagnostics equipment, test equipment, and control systems for DIII-D, PBX, ATF, MTX, and Alcator C-MOD. Continued support of the maintenance manipulator and ICRF hardware for TFTR.	Purchase high power rectifiers and components for heating systems for ATF, C-MOD, and DIII-D, continue 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. Complete fabrication and testing of the maintenance manipulator in TFTR, and continue 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. Complete purchase of main thyristor power supplies for Alcator C-MOD.
Total Confinement Systems	$7,800	$10,110	$11,235
Applied Plasma Physics	Complete acquisition of motor generator supply for the Confinement Physics Research Facility (CPRF) at LANL. Initiated procurment 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 for NMFECC.	Continue procurement and assembly of power handling system for CPRF project. Provide 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.
Total Applied Plasma Physics	$4,500	$3,260	$2,445

III. CAPITAL EQUIPMENT (Cont'd)

Program Activity	FY 1987	FY 1988	FY 1989
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.	Special and general purpose equipment is purchased to increase the efficiency and productivity of the research and development efforts and technology test facilities. Increase provided to support capital equipment needs in the area of heating technology development.
Total Development and Technology	$1,890	$2,480	$4,155
Planning and Projects	Purchase of general purpose equipment to support non-fusion-specific landlord responsibilities at ORNL.	Purchase of 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.
Total Planning and Projects	$3,820	$3,820	$3,800
Total Capital Equipment	$18,010	$19,670	$21,635

CONSTRUCTION

Compact Ignition Tokamak	No Activity	Provides for initiation of architect engineering services.	Effort provides for continuation of design engineering and for long-lead procurement of CIT device components and systems and for initiation of on-site CIT construction.
Total Compact Ignition Tokamak	$0	$8,000	$12,000

III. CONSTRUCTION (Cont'd)

Program Activity	FY 1987	FY 1988	FY 1989
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 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 Projects	$8,200	$8,900	$8,900
Total Construction	$8,200	$16,900	$20,900

DEPARTMENT OF ENERGY
FY 1989 CONGRESSIONAL BUDGET REQUEST
ENERGY SUPPLY RESEARCH AND DEVELOPMENT
OFFICE OF ENERGY RESEARCH
(dollars in thousands)

KEY ACTIVITY SUMMARY

CONSTRUCTION PROJECTS

Magnetic Fusion Energy

IV. A. Construction Project Summary

Project No.	Project Title	Total Prior Year Obligations	FY 1988 Appropriated	FY 1989 Request	Remaining Balance	TEC
Pace Funded						
88-R-92	Compact Ignition Tokamak	$ 0	$ 8,000	$ 12,000	406,000	426,000
GP-E-900	General Plant Projects	0	0	8,900	0	8,900
88-R-901	General Plant Projects	0	8,900	0	0	8,900
Subtotal, MFE Pace Construction		0	16,900	20,900	406,000	
Operating Funded						
-	Field Reversed Configuration	2,350	2,870	2,400	2,120	9,740
-	Alcator C Modification	4,000	4,900	4,900	3,800	17,600
Subtotal, OE Funded		$ 6,350	$ 7,770	$ 7,300	$ 5,920	
Total, MFE Construction		$ 6,350	$ 24,670	$ 28,200	$ 411,920	

DEPARTMENT OF ENERGY
FY 1989 CONGRESSIONAL BUDGET REQUEST
ENERGY SUPPLY RESEARCH AND DEVELOPMENT
OFFICE OF ENERGY RESEARCH
(dollars in thousands)

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: 426,000
Start Date: 3rd Qtr. FY 1988
Completion Date: 1st Qtr. FY 1996

2. Financial schedule:

Fiscal Year	Authorization	Appropriated	Obligations	Costs
1988	$ 8,000	$ 8,000	$ 8,000	$ 8,000
1989	418,000	12,000	12,000	12,000
1990		31,000	31,000	31,000
1991		49,000	49,000	49,000
1992		80,000	80,000	70,000
1993		84,000	84,000	74,000
1994		87,000	87,000	87,000
1995		60,000	60,000	60,000
1996		15,000	15,000	35,000

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 intended 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 $12,000,000 provides for design, procurement and construction of the CIT device components and systems.

DEPARTMENT OF ENERGY
FY 1989 CONGRESSIONAL BUDGET REQUEST
ENERGY SUPPLY RESEARCH AND DEVELOPMENT
OFFICE OF ENERGY RESEARCH
(dollars in thousands)

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: $8,900,000
Start Date: 2nd Qtr. FY 1989
Completion Date: 4th Qtr. FY 1990

2. Financial schedule:

Fiscal Year	Appropriated	Obligations	Costs
1989	$ 8,900	$ 8,900	$ 2,927
After 1989	0	0	5,973

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 1989 by laboratory is as follows:

Los Alamos National Laboratory	$ 500,000
Princeton Plasma Physics Laboratory	1,800,000
Oak Ridge National Laboratory	6,600,000
	$ 8,900,000

DEPARTMENT OF ENERGY
FY 1989 CONGRESSIONAL BUDGET REQUEST
ENERGY SUPPLY RESEARCH AND DEVELOPMENT
OFFICE OF ENERGY RESEARCH
(dollars in thousands)

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: $9,740,0000
Start Date: 4th Qtr. FY 1986
Completion Date: 3rd Qtr. FY 1990

2. Financial schedule:
(Budget Authority)

Prior Year	FY 1987 Actual	FY 1988 Appropriated	FY 1989 Request	To Complete
$ 550	$ 1,800	$ 2,870	$ 2,400	$ 2,120

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) Funds in FY 1989 will be used to continue fabrication and installation work.

DEPARTMENT OF ENERGY
FY 1989 CONGRESSIONAL BUDGET REQUEST
ENERGY SUPPLY RESEARCH AND DEVELOPMENT
OFFICE OF ENERGY RESEARCH
(dollars in thousands)

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: $17,600,000
   Start Date: 1st Qtr. FY 1987
   Completion Date: 3rd Qtr. FY 1990

2. Financial schedule:
   (Budget Authority)

Prior Year	FY 1987 Acutal	FY 1988 Appropriated	FY 1989 Request	To Complete
$ 0	$ 4,000	$ 4,900	$ 4,900	$ 3,800

3. Narrative:

   (a) The Alcator C-Mod. project will provide a unique device, using existing support facilities, to conduct an 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 ICRF heating.

   (c) FY 1989 activities include fabrication and installation of hardware.

DOE/MA-0274

Congressional Budget Request

Non-Defense Activities
Construction Project Data Sheets

FY 1989

U.S. Department of Energy
Assistant Secretary,
Management and Administration
Office of the Controller
Washington, D.C. 20585

February 1988

DEPARTMENT OF ENERGY

FISCAL YEAR 1989 CONGRESSIONAL BUDGET REQUEST

CONSTRUCTION PROJECT DATA SHEETS

ENERGY SUPPLY RESEARCH AND DEVELOPMENT

BASIC RESEARCH USER FACILITIES

GENERAL SCIENCE AND RESEARCH

URANIUM ENRICHMENT

NAVAL PETROLEUM AND OIL SHALE RESERVES

FOSSIL ENERGY RESEARCH AND DEVELOPMENT

NON-DEFENSE CONSTRUCTION PROJECT DATA SHEETS

ENERGY SUPPLY RESEARCH AND DEVELOPMENT

[redacted]

NON-DEFENSE CONSTRUCTION PROJECT DATA SHEETS

ENERGY SUPPLY RESEARCH AND DEVELOPMENT

DEPARTMENT OF ENERGY

FISCAL YEAR 1989 CONGRESSIONAL BUDGET REQUEST

CONSTRUCTION PROJECT DATA SHEETS

ENERGY SUPPLY RESEARCH AND DEVELOPMENT

DEPARTMENT OF ENERGY
FY 1989 CONGRESSIONAL BUDGET SUBMISSION

OPERATING EXPENSE FUNDED PROJECT DATA SHEET
Energy Research

Energy Supply Research and Development - Operating Expenses
Magnetic Fusion

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

Alcator C-Modification (C-MOD)
Massachusetts Institute of Technology

Total Estimated Cost: $17,600,000
(For Design and Construction)

Alcator C-Modification (C-MOD)
Massachusetts Institute of Technology*

Total Estimated Cost: $17,600,000

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

	FY 1987 Actual		FY 1988 Estimate		FY 1989 Estimate		FY 1990 Estimate		Total Project Costs
	B/A	B/O	B/A	B/O	B/A	B/O	B/A	B/O	B/A
Fabrication									
Operating Expenses									
Design and Construction	$ 4,000	$ 4,000	$ 4,900	$ 4,900	$ 4,900	$ 4,900	$ 3,800	$ 3,800	$17,600
Subtotal	4,000	4,000	4,900	4,900	4,900	4,900	3,800	3,800	17,600
Related Funding Requirements									
Research Operations	2,760	2,760	4,500	4,500	3,235	3,235	1,505	1,505	12,000
Capital Equipment	0	0	500	500	3,500	3,500	700	700	4,700
	2,760	2,760	5,000	5,000	6,735	6,735	2,205	2,205	16,700
Total Project	$ 6,760	$ 6,760	$ 9,900	$ 9,900	$11,635	$11,635	$ 6,005	$ 6,005	$34,300

Description, Objective and Justification

The presently operating Alcator-C facility will be modified to Alcator C-MOD, a high-performance tokamak to optimize confinement in a high density, RF-heated plasma with the largest toroidal field operating range in the world. C-MOD will have a double-null divertor, and it will utilize 4-5 MW of ICRF power for auxiliary heating. $3.7M in capital equipment funds are to be used to replace power supplies transferred to LLNL for the Microwave Tokamak Experiment (MTX).

*This project will be constructed at the Massachusetts Institute of Technology which is non-Government property.

Total Estimated Cost: $17,600,000

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

Description, Objective and Justification (continued)

The major objective of Alcator C-MOD is to provide unique and valuable information on transport in high density plasmas with intense ICRF heating. With the high current capability of C-MOD, good confinement is expected. The improved access in C-MOD, together with most recent advances in divertor designs, will make it possible to investigate both the physics and engineering of high field tokamak operation.

During the initial phase of operation, the objective is to develop operational techniques and control methods to produce high-temperature, high-density, well confined plasmas using such tools as a baffled divertor and pellet fueling. Further in the area of particle control, C-Mod will develop operational techniques to improve confinement effects. C-Mod will address issues such as current ramp-up for discharge optimization.

(a) Schedule of Planned Activities

	Start	Complete
Design	1Q FY 1987	4Q FY 1987
Fabrication	3Q FY 1987	2Q FY 1989
Installation	1Q FY 1989	3Q FY 1990
Startup	3Q FY 1990	2Q FY 1991

(b) Management and Contracting

This project will be managed by the MIT Plasma Fusion Center under separate contract.

(c) Prior Year Achievements

Detail design completed. Technology R&D and fabrication initiated.

(d) Current Year Achievements

Technology R&D completed. All components of device under fabrication. Preparation for installation begun.

(e) Reasons for Increases or Decreases

Because of the budget priorities the construction schedule has slipped by six months.

(f) Cost Estimate

Engineering and Design	$ 2,700
Hardware Fabrication and Installation	12,600
Contingency	2,300
Total	$17,600

Escalation at 5% per year.

DEPARTMENT OF ENERGY
FY 1989 CONGRESSIONAL BUDGET SUBMISSION

OPERATING EXPENSE FUNDED PROJECT DATA SHEET
Energy Research

Energy Supply Research and Development - Operating Expenses
Magnetic Fusion

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

Field Reversed Configuration (FRC) Physics Experiment
Spectra Technology

Total Estimated Cost (TEC): $9,740,000
(For Design and Construction)

FRC Physics Experiment
Spectra Technology*

Total Estimated Cost (TEC): $9,740,000

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

	FY 1986 Actual		FY 1987 Actual		FY 1988 Estimate		FY 1989 Estimate		FY 1990 Estimate		Total Project Funding
	B/A	B/O	B/A	B/O	B/A	B/O	B/A	B/O	B/A	B/O	B/A
Fabrication											
Operating Expenses	$ 550	$ 254	$ 1,800	$ 971	$ 2,870	$ 3,067	$ 2,400	$ 4,300	$ 2,120	$ 1,148	$ 9,740
Subtotal	550	254	1,800	971	2,870	3,067	2,400	4,300	2,120	1,148	9,740
Related Funding Requirements											
Research Operations	550	0	1,200	1,074	990	990	920	920	40	716	3,700
Subtotal	550	0	1,200	1,074	990	990	920	920	40	716	3,700
Total Project	$ 1,100	$ 254	$ 3,000	$ 2,045	$ 3,860	$ 4,057	$ 3,320	$ 5,220	$ 2,160	$ 1,864	$13,440

Description, Objective and Justification:

The term field reversed configuration (FRC) refers to a special class of toroidal plasma systems that have elongated cross-sections and are contained in a straight or linear magnetic field. The magnetic field is very simple. Technological advances and increased understanding of FRC physics and formation processes have resulted in rendering the FRC a unique and promising approach to fusion power. Its promise arises from the extremely high beta values (of order unity) and its observed ruggedness.

The objective of this experiment is 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. Present experiments operate at S of 2-3. Immediate extrapolation to the reactor-required S of 30 would be costly. However, theoretical predictions show that at S = 8 conditions are achieved similar to those encountered in a fusion plasma, and this value has been chosen as a cost effective near term goal.

*This project will be constructed at Spectra Technology which is non-Government owned property.

Total Estimated Cost (TEC): $9,740,000

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

Description, Objective and Justification (continued):

The hardware required to meet the experimental objectives are: large diameter plasma discharge tube, vacuum vessel and accompanying support structure, high voltage power supply banks, and ignition switches for capacitors. There will also be costs related to space preparation. The experiment will be designed to achieve a plasma condition of 54-cm-diam, 160-cm length, $2 \times 10^{15} cm^{-3}$ particle density, 300 eV temperature, energy confinement time of 1 millisecond, and fusion Lawson parameter of 2×10^{12} sec-cm^{-3}.

(a) Schedule of Planned Activities

Activity	Start	Completion
Device Design	4Q FY 1986	3Q FY 1987
Fabrication and Installation	2Q FY 1987	3Q FY 1990
Begin Operations	4Q FY 1990	Indefinite

(b) Management and Contracting

The technical requirements and experimental objectives have been established during a technical planning effort with experts in the field reversed configuration topical area. Outside reviews have supported the timing and confirmed the experimental objectives. The contractor is Spectra Technology, in Bellevue, Washington.

(c) Prior Year Achievements

Preliminary and final designs were completed and reviewed. Three research and development power supplies, component testing, and plasma tube modules have been completed. Construction work has started.

(d) Current Year Achievements

Fabrication and installation of FRC components are underway.

Total Estimated Cost (TEC): $9,740,000

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

(e) Reasons for Increases and Decreases

Because of budget priorities a lengthening of the construction schedule has been made necessary resulting in an increase in construction cost from the $9,100,000 shown in the FY 1988 Congressional Budget to the $9,740,000 contained herein.

(f) Cost Estimate (Cost estimate is preliminary).

Engineering and Design	$ 1,430
Procurement and Fabrication	5,330
Assembly and Installation	2,280
Contingency	700
Total	$ 9,740

Escalation is included at 3.5% per year.

DEPARTMENT OF ENERGY
FY 1989 CONGRESSIONAL BUDGET SUBMISSION
CONSTRUCTION PROJECT DATA SHEETS
ENERGY SUPPLY RESEARCH AND DEVELOPMENT - PLANT AND CAPITAL EQUIPMENT
MAGNETIC FUSION

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

1. Title and location of project: General plant projects

2. Project No.: GP-E900

3. Date A-E work initiated: 1st Qtr. FY 1989

3a. Date physical construction starts: 2nd Qtr. FY 1989

4. Date construction ends: 4th Qtr. FY 1990

5. Previous cost estimate: None
Date:

6. Current cost estimate: $8,900
Date: January 1988

7. Financial Schedule:

Fiscal Year	Obligations	Costs FY 1987	FY 1988	FY 1989	After FY 1989
Prior Year Projects	XXXXXXXX	$ 5,142	$ 6,240	$ 2,944	$ 0
FY 1987 Projects	$ 8,200	2,711	3,099	2,390	0
FY 1988 Projects	8,900	0	2,848	4,005	2,047
FY 1989 Projects	8,900	0	0	2,848	6,052
		$ 7,853	$ 12,187	$ 12,187	$ 8,099

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 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.

1. Title and location of project: General plant projects   2. Project No.: GP-E900

8. Brief Physical Description of Project (continued)

The currently estimated distribution of FY 1989 funds by office is as follows:

1. Los Alamos National Laboratory	$ 500
2. Princeton Plasma Physics Laboratory	1,800
3. Oak Ridge National Laboratory	6,600
	$ 8,900

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

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

Los Alamos National Laboratory		$ 500
CPRF Control Room Mods	155	
Power Systems Enclosures	260	
Miscellaneous small projects	85	
Princeton Plasma Physics Laboratory*		$ 1,800
Ion Source Maintenance Building	475	
Safety and Fire Protection System Improvements	125	
CICADA Uninterruptible Power Supply	450	
Electric Power Modifications	450	
Building Roof Replacement and Structural Reinforcing	300	

*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 | 2. Project No.: GP-E900

9. Purpose Justification of Need for, and Scope of Project (continued)

Oak Ridge National Laboratory..$ 6,600

These funds cover the Magnetic Fusion Energy program's responsibility to fund all of the generic general plant projects needs at this multipurpose laboratory.

Modernize Switchg-ear, Mammalian Genetics Laboratory........................	$ 200
Replace Temporary Onstreet Parking..	80
Air Condition Greenhouse, Controlled Environment and Animal Building........	100
Upgrade Laboratory Air Conditioning...	650
Construct Internal Storage Area, Fusion Energy Administration Laboratory Building..	270
Balance Negative Air Pressure, Fusion Energy Administration & Research Building, Phase V..	1,000
Replace Back-Up Compressor, Steam Plant.....................................	350
Materials Storage Silo, Coal Yard Runoff....................................	100
Upgrade Substation, Fusion Energy Administration Laboratory.................	650
Walker Branch Watershed Laboratory..	275
Restoration of HVAC System, Northeast Quadrant, Fusion Energy Building......	1,075
Replace #2 Elevator, Biology Building.......................................	300
Sentry Post Replacement...	210
Replace 480v Electrical Systems, Fusion Energy Building.....................	500
Replace 480v Switchgear, Fusion Energy Engineering Technology Building, Phase I..	400
Pedestrian Safety Improvements..	40
Safety and Functional Improvements to the Metal Storage and Cutting Facility..	130
Provide Weld Test and Development Shop......................................	270

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.

1. Title and location of project: General plant projects 2. Project No.: GP-E900

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.

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

This item does not apply to general plant projects.

DEPARTMENT OF ENERGY
FY 1989 CONGRESSIONAL BUDGET SUBMISSION
CONSTRUCTION PROJECT DATA SHEETS
ENERGY SUPPLY RESEARCH AND DEVELOPMENT - PLANT AND CAPITAL EQUIPMENT
MAGNETIC FUSION

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

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1. Title and location of project: Compact ignition tokamak (CIT)
Princeton Plasma Physics Laboratory (PPPL)*

2. Project No.: 89-R-92

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3. Date A-E work initiated: 3rd Qtr. FY 1988

3a. Date physical construction starts: 3rd Qtr. FY 1989

4. Date construction ends: 1st. Qtr FY 1996**

5. Previous cost estimate: 357,000
Date: January 1987

6. Current cost estimate: 426,000**
Date: January 1988

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7. Financial Schedule:

Fiscal Year	Authorization	Appropriation	Obligations	Costs
1988	$ 8,000	$ 8,000	$ 8,000	$ 8,000
1989	418,000	12,000	12,000	12,000
1990		31,000	31,000	31,000
1991		49,000	49,000	49,000
1992		80,000	80,000	70,000
1993		84,000	84,000	74,000
1994		87,000	87,000	87,000
1995		60,000	60,000	60,000
1996		15,000	15,000	35,000

8. Brief Physical Description of Project

The design of CIT will be based on the reconfiguration of the Tokamak Fusion Test Reactor (TFTR) facilities into an ignition facility. The TFTR facilities include buildings, power supplies, motor generators, a tritium system, vacuum pumping systems, computer control systems, instrumentation systems, a water cooling system, utilities, and diagnostics which are relevant to the CIT Project objective of investigating burning plasma conditions in a tokamk configuration.

* 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.

**The project schedule and cost estimate have been adjusted to reflect the impact of reduced project budget levels in FY 1989, FY 1990 and FY 1991.

1. Title and location of project: Compact ignition tokamak (CIT) Princeton Plasma Physics Laboratory (PPPL)

2. Project No.: 88-R-92

8. Brief Physical Description of Project (Continued)

Construction of the CIT facility will include the following new facilities:

- A high magnetic field tokamak device with support structure, vacuum vessel, vacuum pumping system, liquid nitrogen cooled copper coils, and support systems.

- A concrete test cell to accommodate the tokamak device and its support systems.

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. A key science issue in establishing this fusion scientific base is understanding the properties of burning plasmas. Achievement of ignition and plasma burn has been an objective of the fusion program from its inception. This CIT project is designed to address this critical burning plasma fusion science issue.

The CIT project also supports the schedule and 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 present generation of operating tokamaks is exploring plasma confinement at near-reactor parameters. A consensus has developed among the leaders of the international fusion community that the fusion program would greatly benefit, and the international ITER objectives would be served, if burning plasma could be produced and studied within the coming decade. CIT will bridge the gap between the transient, subignited operation of TFTR in the U.S. and JET in Europe and the stable equilibrium burn projected for the international ITER. Thus, the objectives for this ignition experiment are that it achieve and reveal the properties of burning plasma well before the operation of the international ITER, at a relatively modest cost compared to the cost of an ITER.

1. Title and location of project: Compact ignition tokamak (CIT) Princeton Plasma Physics Laboratory (PPPL)

2. Project No.: 88-R-92

9. Purpose, Justification of Need for, and Scope of Project (Cont'd)

The CIT project provides a new tokamak device in 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.

The funding request of $12,000,000 in FY 1989 provides for continuation of engineering, for long-lead procurement of CIT device components and for initiation of on-site CIT construction.

10. Details of Cost Estimate

	Item Cost	Total Cost
a. Engineering Design and Inspection		96,000
b. Construction Costs		237,000
(1) Improvements to land, including grading, drainage, roads, paving, area lighting and landscaping	700	
(2) Buildings		
(a) New buildings to house CIT, approximately 60,000 square feet	30,000	
(3) Special facilities	198,800	
(4) Utilities including (mechancial) communications and electrical power	7,500	
Subtotal		333,000
c. Contingency at approximately 28% of above costs		93,000
Total Estimated Cost		426,000

1. Title and location of project: Compact ignition tokamak (CIT)
Princeton Plasma Physics Laboratory (PPPL)

2. Project No.: 88-R-92

11. Method of Performance

The design, engineering, fabrication, and installation for CIT will be an effort involving the participation of several national laboratories, other DOE research centers, and possible international cooperation. A fusion program objective is for CIT 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 CIT technical and scientific challenges and progress.

The design of conventional facilities will be on the basis of a negotiated architect-engineer or construction management contract. The design of special facilities will be by PPPL, MIT, ANL, ORNL, INEL, LANL, LLNL, the FEDC and other industrial contractors. PPPL will have responsibility for the overall design integration and configuration control.

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

	FY 1988	FY 1989	FY 1990	FY 1991	FY 1992	FY 1993	FY 1994	FY 1995	FY 1996	Total
a. Total Project Funding										
1. Total Facility Costs	8,000	12,000	31,000	49,000	70,000	74,000	87,000	60,000	35,000	426,000
2. Other Project Funding*										
(a) Diagnostics*		500	1,500	2,700	7,000	9,000	7,000	7,000	7,000	41,700
(b) R&D Necessary to Complete Construction	5,700	13,000	7,800	5,000						31,500
(c) Other Project Related Costs*	1,810	1,500	5,700	7,300	8,000	8,000	8,000	8,000	9,000	57,310
Total Other Project Funding	7,510	15,000	15,000	15,000	15,000	17,000	15,000	15,000	16,000	130,510
Total Project Funding	15,510	27,000	46,000	64,000	85,000	91,000	102,000	75,000	51,000	556,510

* These funding schedules have been adjusted to reflect the longer project schedule. The level-of-effort costs have been continued and included in the additional years FY 1994, FY 1995, and FY 1996.

1. Title and location of project: Compact ignition tokamak (CIT)
Princeton Plasma Physics Laboratory (PPPL)

2. Project No.: 88-R-92

12. Funding Schedule of Project Funding and Other Related Funding Requirements (Continued)

b. Other Related Annual Costs

	Annual Estimates
1. Facility operating costs..........	$ 50,000
2. Programmatic operating expenses directly related to the facility..........	25,500
3. Capital equipment not related to construction, but related to the programmatic effort in the facility..........	4,500
Total Related Annual Costs..........	80,000

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

a. Total Project Funding

1. Total Facility Costs - Description is provided in Sections 8 and 9.

2. Other Project Funding

(a) Diagnostics

Diagnostics consist of designing, manufacturing, testing and maintaining the new and modified experimental systems for evaluating plasma performance.

(b) 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 and first wall, remote maintenance, shielding, and instrumentation and control systems.

The project also depends upon the continued role of the fusion laboratories to support the technology research and development activities necessary to successfully complete CIT. Accordingly, continued adequate funding of the fusion base program is implied.

1. Title and location of project: Compact ignition tokamak (CIT)
Princeton Plasma Physics Laboratory (PPPL)

2. Project No.: 88-R-92

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

(c) Other Project Related Costs

These costs include spare parts, and auxiliary components, system software development and maintenance, and physics and other supplemental staff support.

b. Other Related Annual Costs

These cost estimates in FY 1989 dollars are for:

1. Facility Operating Costs

This facility is estimated to operate for a period of 7 years. The major elements comprising the annual operating costs will be personnel salaries, materials and services, maintenance, spare parts, and utilities.

2. Programmatic Operating Expenses Directly Related to the Facility

The programmatic operating expenses directly related to the facility will be salaries for staff personnel (physicists and engineers) to carry out the experimental program.

3. Capital Equipment Not Related to Construction but Related to the Programmatic Effort in the Facility.

Capital equipment not related to construction but related to the programmatic effort.