DOE/MA-0064/4
Volume 3 of 7

Congressional Budget Request

Energy Supply Research and Development

Volume 3

FY 1987

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

February 1986

DEPARTMENT OF ENERGY

FISCAL YEAR 1987 CONGRESSIONAL BUDGET REQUEST

ENERGY SUPPLY RESEARCH AND DEVELOPMENT

VOLUME 3

TABLE OF CONTENTS

Summary of Estimate by Appropriation 3

Summary of Staffing by Subcommittee 5

Summary of Staffing by Appropriation 6

Appropriation Language 7

Summary of Estimates by Major Activities 8

Environment, Safety and Health 9

Liquefied Gaseous Fuels Spill Test Facility 51

Biological and Environmental Research 59

Magnetic Fusion 91

Supporting Research and Technical Analysis 141

Supporting Services 379

DEPARTMENT OF ENERGY

FISCAL YEAR 1987 CONGRESSIONAL BUDGET REQUEST

SUMMARY OF ESTIMATES BY APPROPRIATIONS

(in thousands of dollars)

	FY 1985 Actual BA	FY 1986 Estimate BA	FY 1987 Request BA
Appropriations Before The Energy and Water Development Subcommittees:			
Energy Supply Research and Development	1,967,490	1,696,298	1,254,162
Uranium Enrichment	237,956	190,512	---
General Science and Research	724,860	655,928	773,400
Atomic Energy Defense Activities ..	7,322,321	7,231,664	8,230,000
Departmental Administration	128,602	150,319	151,082
Alaska Power Administration	3,233	3,245	2,881
Bonneville Power Administration ...	284,771	330,000	276,100
Southeastern Power Administration .	35,744	---	19,647
Southwestern Power Administration .	31,208	29,191	25,337
Western Area Power Administration .	218,230	195,910	240,309
Western Area Power Emergency Fund .	---	---	---
Federal Energy Regulatory Commission	54,543	41,989	20,325
Nuclear Waste Fund	327,669	499,037	769,349
Geothermal Resources Development Fund	121	69	72
Subtotal, Appropriations Before the Energy and Water Development Subcommittees	$11,336,748	$11,024,162	$11,762,664

DEPARTMENT OF ENERGY

FISCAL YEAR 1987 CONGRESSIONAL BUDGET REQUEST

SUMMARY OF ESTIMATES BY APPROPRIATIONS

(in thousands of dollars)

	FY 1985 Actual BA	FY 1986 Estimate BA	FY 1987 Request BA
Appropriations Before Interior and Related Agencies Subcommittees:			
Alternative Fuels Production	$ 1,169,895	$ ---	$ ---
Clean Coal Technology	---	---	---
Fossil Energy Research and Development	289,048	311,954	82,767
Naval Petroleum and Oil Shale Reserves	156,874	13,002	127,108
Energy Conservation	457,436	427,512	39,433
Energy Regulation	27,139	23,423	21,850
Emergency Preparedness	6,045	5,750	6,044
Strategic Petroleum Reserve	2,049,550	107,533	---
Energy Information Activities	60,919	57,724	59,651
Subtotal, Interior and Related Agencies Subcommittees	4,216,906	946,898	336,853
Subtotal, Energy and Water Development Subcommittees	11,336,748	11,024,162	11,762,664
Subtotal, Department of Energy	15,553,654	11,971,060	12,099,517
Permanent - Indefinite Appropriations:			
Payments to States	1,052	570	570
Total, Department of Energy	$15,554,706	$11,971,630	$12,100,087

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL STAFFING REQUEST
TOTAL WORK FORCE

	FY1985 FTE USAGE	FY1986 CONGR REQ	FY1987 -FY86	FY1987 CONGR REQ
ENERGY & WATER SUBCOMMITTEE				
HEADQUARTERS	4,865	4,965	-18	4,947
FIELD	9,133	9,185	111	9,296
SUBCOMMITTEE TOTAL	13,998	14,150	93	14,243
INTERIOR SUBCOMMITTEE				
HEADQUARTERS	1,353	1,304	-166	1,138
FIELD	907	896	-226	670
SUBCOMMITTEE TOTAL	2,260	2,200	-392	1,808
GRAND TOTAL	16,258	16,350	-299	16,051
ADJUSTMENT		-132	-198	-330
ADJUSTED TOTAL	16,258	16,218	-497	15,721

Department of Energy
FY 1987 Congressional Staffing Request
Total Work Force

	FY1985 FTE USAGE	FY1986 CONGR REQ	FY1987 -FY86	FY1987 CONGR REQ
10:ENERGY SUPPLY RESEARCH AND DEV	937	934	-34	900
HEADQUARTERS	811	820	-28	792
FIELD	126	114	-6	108
15:URANIUM ENRICHMENT	69	66	1	67
HEADQUARTERS	58	55	1	56
FIELD	11	11	0	11
20:GENERAL SCIENCE AND RESEARCH	37	39	0	39
HEADQUARTERS	37	39	0	39
25:ATOMIC ENERGY DEFENSE ACTIVITI	2,618	2,702	131	2,833
HEADQUARTERS	496	518	9	527
FIELD	2,122	2,184	122	2,306
30:DEPARTMENTAL ADMINISTRATION	3,307	3,332	-5	3,327
HEADQUARTERS	1,721	1,726	0	1,726
FIELD	1,586	1,606	-5	1,601
34:ALASKA POWER ADMINISTRATION	37	38	0	38
FIELD	37	38	0	38
36:BONNEVILLE POWER ADMIN	3,510	3,480	0	3,480
FIELD	3,510	3,480	0	3,480
38:SOUTHEASTERN POWER ADMIN	38	40	0	40
FIELD	38	40	0	40
42:SOUTHWESTERN POWER ADMIN	186	186	0	186
FIELD	186	186	0	186
46:WESTERN AREA POWER ADMIN	1,181	1,160	0	1,160
FIELD	1,181	1,160	0	1,160
50:WAPA - COLORADO RIVER BASIN	219	219	0	219
FIELD	219	219	0	219
52:FEDERAL ENERGY REGULATORY COMM	1,617	1,659	0	1,659
HEADQUARTERS	1,617	1,659	0	1,659
54:NUCLEAR WASTE FUND	238	292	0	292
HEADQUARTERS	123	147	0	147
FIELD	115	145	0	145
56:GEOTHERMAL RESOURCES DEV FUND	2	1	0	1
HEADQUARTERS	2	1	0	1
65:FOSSIL ENERGY RESEARCH AND DEV	714	700	-161	539
HEADQUARTERS	151	135	-26	109
FIELD	563	565	-135	430
70:NAVAL PETROL & OIL SHALE RES	104	104	-9	95
HEADQUARTERS	23	23	0	23
FIELD	81	81	-9	72
75:ENERGY CONSERVATION	333	352	-134	218
HEADQUARTERS	208	227	-79	148
FIELD	125	125	-55	70
80:EMERGENCY PREPAREDNESS	74	71	0	71
HEADQUARTERS	74	71	0	71
81:ECONOMIC REGULATION	377	340	-50	290
HEADQUARTERS	377	340	-50	290
85:STRATEGIC PETROLEUM RESERVE	178	152	-32	120
HEADQUARTERS	40	27	-5	22
FIELD	138	125	-27	98
90:ENERGY INFORMATION ACTIVITIES	480	481	-6	475
HEADQUARTERS	480	481	-6	475
94:ADVANCES FOR CO-OP WORK	2	2	0	2
FIELD	2	2	0	2
GRAND TOTAL	16,258	16,350	-299	16,051
ADJUSTMENT		-132	-198	-330
ADJUSTED TOTAL	16,258	16,218	-497	15,721

DEPARTMENT OF ENERGY

Proposed Appropriation Language

Energy Supply, Research and Development Activities

(Including Transfer of Funds)

For expenses of the Department of Energy activities including the purchase, construction and acquisition of plant and capital equipment and other expenses incidental thereto necessary for energy supply, research and development activities, and other activities in carrying out the purposes of the Department of Energy Organization Act (Public Law 95-91), including the acquisition or condemnation of any real property or any facility or for plant or facility acquisition, construction or expansion; purchase of passenger motor vehicles (not to exceed [17] 18 for replacement only), [$1,989,671,000] $1,254,162, to remain available until expended [of which $200,000,000]; in addition, $584,158,000 shall be derived by transfer from Uranium Supply and Enrichment Activities provided in prior years[, and of which $17,400,000 shall be derived by transfer from Operation and Maintenance, Southeastern Power Administration; and of which $25,000,000 shall be available only for construction of]: Provided, That funds available under this head in Public Law 99-141 for the Advanced Science Center, the Center for Science and Technology, the Center for Energy and Biomedical Technology, the Energy and Mineral Research Center, and the Demonstration Center for Information Technologies [as described in the report accompanying this Act; together with not to exceed $6,000,000, to be derived from revenues from activities of the Technical Information Services, which shall be credited to this account and used for necessary expenses and shall remain available until expended], shall be available for other expenses of energy supply, research and development activities. (Public Law 99-141, making appropriations for energy and water development, 1986.)

DEPARTMENT OF ENERGY

FISCAL YEAR 1987 CONGRESSIONAL BUDGET REQUEST

SUMMARY OF ESTIMATES BY APPROPRIATION BY MAJOR ACTIVITY

ENERGY SUPPLY RESEARCH AND DEVELOPMENT

[Budget Authority in Thousands of Dollars]

	FY 1985 Actual	FY 1986 Estimate	FY 1987 Request
Solar Energy	$ 171,587	$ 144,624	$ 72,292
Geothermal	29,698	26,681	17,930
Hydropower	447	481	---
Electric Energy Systems	19,717	11,548	7,619
Energy Storage Systems	18,642	17,292	8,000
Nuclear Energy R&D	412,612	374,684	330,900
Remedial Action & Waste Technology .	170,365	230,047	294,100
Civilian Waste R&D	25,806	16,064	6,500
Environmental, Safety and Health ...	38,063	46,921	76,098
Biological and Environmental Research	187,746	179,950	196,565
Liquified Gaseous Spill Test Facility	4,289	1,732	1,200
Magnetic Fusion	429,553	365,469	333,000
Basic Energy Sciences	410,800	433,770	441,370
Energy Research Analysis	2,970	2,598	3,550
University Research Instrumentation.	4,950	6,254	5,000
University Research Support	10,059	10,296	10,975
Advisory and Oversight Program Direction	2,900	2,674	2,900
Multi-Program Laboratories Facilities Support	33,200	39,824	60,190
Small Business Innovation Research Program	24,724	---	---
In-House Energy Management	14,821	11,709	16,500
Technical Information and Management	13,442	12,413	10,775
Policy and Management	3,380	3,497	3,887
Subtotal, Energy Supply R&D ...	2,029,890	1,939,528	1,899,951
Less Use of Prior Year Balances and Other Adjustment	-62,400	-243,230	-645,789
Total, Energy Supply R&D............	$1,967,490	$1,696,298	$1,254,162

MAGNETIC FUSION

DEPARTMENT OF ENERGY
1987 CONGRESSIONAL BUDGET REQUEST
PROGRAM OVERVIEW

Magnetic Fusion Energy

The goal of the National Energy Policy Plan is to foster an adequate supply of energy at reasonable costs. The Magnetic Fusion Energy program is an element of this program. The goal of this program is to establish the scientific and technological base required for fusion energy. The program is making good technical progress toward this goal. The long term need and desirability for fusion energy continues to be strong. However, the program plan and the program budgets have been adjusted to reflect improvements in our near term energy supply as well as the need for austerity in federal spending. In this situation, international collaboration is being used as a key resource to support achievement of the program goal in a timely fashion.

The development of magnetic fusion could lead to economic energy sources that possess a secure fuel reserve, as well as acceptable environmental and safety features. The fuel, deuterium and tritium from lithium, is readily available and its supply is essentially unlimited. Potential end use applications are electricity generation, the production of synthetic fuels, nuclear fuels, and high grade heat for industrial applications.

Nearer term benefits of fusion development include an increase in the understanding of plasma physics and related scientific fields. Fusion also attracts and trains outstanding scientists and engineers. Fusion-related science combines plasma physics, atomic physics, nuclear physics, surface and solid state physics, and advanced computational techniques. Fusion-related technology involves superconducting systems, large magnetic systems, high power radio frequency heating systems, tritium systems, high heat flux energy recovery systems, advanced materials development, nuclear technology, real time computer control, sophisticated instrumentation, unique vacuum systems, and particle beam heating systems. The technology developed in support of fusion research has many applications in science and industry.

Over the last decade, a significant investment in equipment and facilities has been made and a core group of skilled scientists and engineers has been trained. With this investment in place, excellent and sustained progress is being made. We have reached a point now where there is general agreement that the remaining technical problems can be solved. With a sustained effort the program goal can be achieved by the time the need for new energy sources becomes acute.

The FY 1987 budget request has been developed to take advantage of the technical position that has already been established in fusion research. It will allow a continuation of cost effective progress toward the development of fusion power as a future energy option and positions the program to support the President's Geneva initiative on international cooperation in this area.

The request of $333 million represents the level of resources required to sustain an effective program. To maintain progress at this level of funding, the program has been narrowed to pursue only toroidal confinement systems. In addition, we have identified the highest priority tasks, improved the cost effectiveness of facility operations, and increased the use of international collaboration. The program has been focused to address four key technical issues; namely, the development of magnetic confinement systems, understanding of scientific principles of a burning plasma, the development of materials for fusion applications, and the development of fusion nuclear technology.

Resolution of the first issue requires the scientific understanding of magnetic confinement systems in order to develop a desirable fusion reactor system. This budget supports the minimum set of experiments to obtain this understanding. There are two principal approaches to confining a plasma magnetically: the toroidal and linear concepts. In the past, the U.S. has pursued both approaches. Beginning in 1987, such breadth is no longer feasible. The U.S. program will focus on development of only the toroidal confinement concept. The tokamak is the most advanced in terms of performance within the toroidal category. However, by studying related toroidal configurations, a better understanding of toroidal confinement will be achieved than if only the tokamak were studied. This strategy will most readily lead to improvement in tokamaks and the development of superior magnetic geometries for practical application in the future. Consequently, this budget request covers work on the tokamak, reversed field pinch, stellarator, and compact toroid variations of toroidal magnetic confinement.

The second technical issue requires the development of a facility to investigate the properties of burning plasmas. A fusion plasma burns when the heat released within the plasma by the fusion reaction is sufficient to maintain the plasma temperature in the face of heat loss from the system. The requirements for ignition should become clear from experiments planned for the Tokamak Fusion Test Reactor at Princeton, during the latter part of the 1980's. Following this achievement, at least one ignited and burning plasma must be produced and studied to complete the scientific data base. This budget supports the necessary preparatory design studies for such a facility.

The third technical issue--materials for fusion systems--affects the ultimate economic and environmental acceptability of a fusion system. Development of the desired materials must be undertaken now because of the long lead time for the required research. This budget supports a level of activity in this area necessary to establish effective international collaboration.

The fourth issue--nuclear technology for fusion systems--includes developing a fusion "blanket" that must convert the energy released by a fusion reaction into useful energy, as well as creating part of the fuel for the reactor. This budget request provides for the most essential preparatory research which will be needed to develop an acceptable blanket in future years.

The FY 1987 budget request of $333 million will maintain some effort in each of the four key technical issues. At this level the FY 1986 initiatives needed to implement the revised program plan continue while other program elements are delayed or deferred. In the Applied Plasma Physics subprogram, a core base of research is maintained. The two major device fabrication projects that were initiated in FY 1986, the reversed field pinch experiment and a compact toroid experiment will be continued. In the Confinement Systems subprogram, TFTR will attempt to reach break-even conditions in deuterium plasmas and preparations will continue for limited D-T operation in 1989. As part of the US/Japan cooperation program, Doublet III will explore beta limits with shaped plasmas. Collaboration abroad, especially on European tokamaks, will continue. Collaboration on these tokamaks allows the U.S. to gain valuable information while avoiding duplication. Studies to support expanded collaboration with the Soviets will begin. In the tandem mirror area, the TMX-U and TARA experimental programs will be completed. The MFTF-B will be mothballed. In the Development and Technology subprogram, design studies on an experiment to study the physics of ignition will be continued. Facility design and development of ion cyclotron radio frequency heating components will be emphasized. The six coil test in the

International Fusion Superconducting Magnet Test Facility at Oak Ridge National Laboratory will be completed. The ongoing materials program will be maintained at an adequate level to support international collaboration in this area, and small scale laboratory tests of critical blanket issues will be carried out.

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
MAGNETIC FUSION ENERGY
ENERGY SUPPLY RESEARCH AND DEVELOPMENT - OPERATING EXPENSES
ENERGY SUPPLY RESEARCH AND DEVELOPMENT - PLANT AND CAPITAL EQUIPMENT
(Tabular dollars in thousands. Narrative material in whole dollars.)

	FY 1985 Appropriation	FY 1986 Appropriation	FY 1987 Base	FY 1987 Request	Request vs Base
Magnetic Fusion Energy					
Applied plasma physics					
Operating Expenses.......	$ 78,937	$ 69,692	$ 69,692	$ 70,700	$+ 1,008
Capital Equipment........	3,170	5,619	5,619	4,500	- 1,119
Subtotal................	82,107	75,311	75,311	75,200	- 111
Confinement systems					
Operating Expenses.......	206,395	188,650	188,650	177,500	-11,150
Capital Equipment........	15,400	14,529	14,529	7,100	- 7,429
Subtotal................	221,795	203,179	203,179	184,600	-18,579
Development and technology					
Operating Expenses.......	67,900	57,059	57,059	50,510	- 6,549
Capital Equipment........	5,100	4,330	4,330	1,890	- 2,440
Subtotal................	73,000	61,389	61,389	52,400	- 8,989
Planning and projects					
Operating Expenses.......	12,201	5,528	5,528	4,780	- 748
Capital Equipment........	3,800	3,801	3,801	3,820	+ 19
Construction............	32,500	12,653	12,653	8,200	- 4,453
Subtotal................	48,501	21,982	21,982	16,800	- 5,182
Program Direction					
Operating Expenses.......	4,150	3,608	3,608	4,000	+ 392
Subtotal................	4,150	3,608	3,608	4,000	+ 392
Total					
Operating Expenses.......	369,583	324,537	324,537	307,490	-17,047
Capital Equipment........	27,470	28,279	28,279	17,310	-10,969
Construction............	32,500	12,653	12,653	8,200	- 4,453
Magnetic Fusion Energy.....	$429,553 a/ b/	$365,469 b/ c/	$365,469	$333,000 b/	$-32,469
Staffing Total FTE's.......	66	62	62	62	--

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

a/ FY 1985 total does not include $3,671,000 transferred to the SBIR program. The FY 1985 total reflects a reduction of $2,940,000 for ADP general reduction.

b/ Total reflects a reduction of $7,194,000 in FY 1985, $10,000,000 in FY 1986, and $10,811,000 in FY 1987 for management initiative savings.

c/ FY 1986 reflects the following comparability changes: $673,000 from Development and Technology to Planning and Projects for inventories, $15,395,000 from Planning and Projects to Confinement Systems for MFTF-B, and $3,989,000 from Applied Plasma Physics to Planning and Projects for Small Business Innovative Research. This aligns the FY 1986 funds consistent with the budget allocation in FY 1987. Total reduced by $14,358,000 in accordance with P.L. 99-177, the Balanced Budget and Emergency Deficit Control Act of 1985 (Gramm-Rudman-Hollings).

Department of Energy

FY 1987 Congressional Budget Request

Adjustments to FY 1986 Appropriations

	FY 1986 Confer.	General Reduction	Management Initiatives	Pay Cost Restoration	FTE General Reduction	Gramm-Rudman-Hollings	ES&H Transfer/ Reprogramming	Subtotal	Comparability Adjustments	Total
Magnetic Fusion Energy										
Applied Plasma Physics										
Operating Expenses	$ 78,100	$ -1,500	$ -25			$ -2,894		$ 73,681	$ -3,989	$ 69,692
Capital Equipment	6,400	—	-560			-221		5,619	—	5,629
Subtotal	84,500	-1,500	-585			-3,115		79,300	-3,989	75,311
Confinement Systems										
Operating Expenses	184,900	-4,000	-840			-6,806		173,255	15,395	188,650
Capital Equipment	15,100	—	—			-571		14,529	—	14,529
Subtotal	200,000	-4,000	-840			-7,376		187,784	15,395	203,179
Development and Technology										
Operating Expenses	62,500	-2,500	—			-2,268		57,732	-673	57,059
Capital Equipment	5,000	—	-500			-170		4,330	—	4,330
Subtotal	67,500	-2,500	-500			-2,438		62,062	-673	61,389
Planning and Projects										
Operating Expenses	16,900					-639		16,261	-10,733	5,528
Capital Equipment	3,950					-149		3,801	—	3,801
Construction	13,150					-497		12,653	—	12,653
Subtotal	34,000					-1,285		32,715	-10,733	21,982
Program Direction										
Operating Expenses	4,000	-181			-67	-144		3,608		3,608
Subtotal, Magnetic Fusion Energy	390,000	-8,181	-1,925		-67	-14,358		365,469	—	365,469
General Reduction:										
Operating Expenses	-8,181	8,181								
Capital Equipment	—	—								
Construction										
Total, General Reductions	-8,181	8,181								
Management Initiatives:										
Operating Expenses	-865		865							
Capital Equipment	-1,060		1,060							
Construction	—		—							
Total, Management Initiatives	-1,925		1,925							
Pay Restoration										

	FY 1986 Confer. (1)	General Reduction (2)	Management Initiatives (3)	Pay Cost Restoration (4)	General Reduction (5)	Rudman-Hollings (6)	Transfer/ Reprogramming (7)	Subtotal (8)	Comparability Adjustments (9)	Total (10)
Use of Prior Year Balances (Magnetic Fusion)										
Operating Expenses										
Capital Equipment										
Construction										
Total, Prior Year Bal. (Magnetic Fusion)										
Use of Prior Year Balances (Other Energy Supply)										
Operating Expenses										
Capital Equipment										
Construction										
Total, Prior Year Bal. (Other Energy Supply)										
Total, Magnetic Fusion Energy.	$379,894				-67	$-14,358		$365,469		$365,469
Operating Expenses	337,354				-67	-12,750		324,537		324,537
Capital Equipment	29,390					-1,111		28,279		28,279
Construction	13,150					-497		12,653		12,653

DEPARTMENT OF ENERGY
1987 CONGRESSIONAL BUDGET REQUEST
SUMMARY OF CHANGES
MAGNETIC FUSION ENERGY
(In thousands of dollars)

1986 Appropriation enacted..	$379,827
1986 Gramm-Rudman reduction..	-14,358
1987 adjusted..	365,469

Program increases and decreases:

Applied Plasma Physics

o This decrease reflects cutbacks in selected lower priority areas primarily in theory and small-scale experimental research support....	- 111

Confinement Systems

o This decrease is primarily associated with focusing the program on the toroidal confinement configuration and completing efforts on the mirror program..	-18,579

Development and Technology

o This decrease is primarily associated with an effort to focus on the most critical technology issues..	- 8,989

Planning and Projects

o A significant portion of this reduction is associated with the completion of MFTF-B construction..	- 5,182

Program Direction .

o Provide support for 62 FTE's..	+ 392
1987 budget request..	$333,000

	FY 1985	FY 1986	FY 1987 Request
I. Applied Plasma Physics........................	$82,107	$75,311	$75,200
A. Operating Expenses........................	78,937	69,692	70,700

The Applied Plasma Physics subprogram develops fusion knowledge through theoretical studies and small experiments that complement the larger Confinement Systems experiments and help to assure that fusion development advances steadily and cost effectively. Working closely with the Confinement Systems subprogram, Applied Plasma Physics plays a key role in the technical issue of developing magnetic confinement systems. Applied Plasma Physics also helps to establish the basis for understanding burning plasmas through its theoretical and diagnostics development activities. It contributes to the task of developing fusion materials led by the Development and Technology subprogram through its theoretical and experimental research on plasma-wall interaction. The Applied Plasma Physics subprogram is people and idea intensive. As a result, international activities in this area concentrate on workshops for discussion of ideas and longer term exchange of individual scientists for collaborative theoretical or experimental research. Through international steering committees and individual meetings, subprogram representatives seek to coordinate research activities with those of other countries to integrate areas of common interest.

Specifically, this subprogram is responsible for fusion theory, for experimental plasma research on small devices, for fusion-related atomic physics, and for development of new diagnostic techniques required to determine plasma behavior. The subprogram is also responsible for developing and testing alternate fusion confinement concepts that are not yet advanced to the point of Confinement Systems tests. Through its support of university research, this subprogram trains a large percentage of the scientists employed in all areas of the fusion program. It also manages the Magnetic Fusion Energy Computer Network that provides all of the large scale computing used by the fusion program for experimental data analysis, theoretical modeling, experimental design, and system studies.

In FY 1987, Applied Plasma Physics will continue several important tasks begun in FY 1986. Fabrication of upgraded reversed field pinch and compact toroid experiments will be continued to allow study of plasmas closer to fusion conditions in these attractive subclasses of the toroidal confinement concept. Tests of several promising theoretical ideas for tokamak improvements will be continued in small-scale experiments. More realistic models of fusion plasma behavior will be developed and tested, aided by the installation of the Cray 2 computer, the first of this new generation, at the National Magnetic Fusion Computer Center.

	FY 1985	FY 1986	FY 1987 Request
(1) Advanced Fusion Concepts.............	22,465	19,558	21,900

The Advanced Fusion Concepts category supports operation of modest scale experimental devices that investigate improvements in fusion confinement. Crucial physics tests of innovative plasma-magnetic field configurations are conducted to advance and broaden the range of understanding of plasma behavior. This level of testing extends from exploratory examination of novel approaches to intensive study of more mature innovative concepts. Research is conducted in national laboratories, industries and several universities. This activity contributes to the resolution of one of the key program technical issues, the development of magnetic systems, through the exploration of non-tokamak toroidal configurations with potentially attractive features. The majority of this effort is devoted to two toroidal confinement approaches, the reversed field pinch (RFP) and the compact toroid. Fundamentally new plasma behavior that could improve the attractiveness of fusion as an energy source has been discovered in this research. Those discoveries have made possible significant progress in these approaches and may be applicable to the tokamak as well. The discoveries resulted not only from experiments in the U.S., but also from related work in Italy, Japan, and the Soviet Union that has been closely coupled to our own efforts.

Therefore, the requested budget will be used to support an important shift in emphasis that was initiated in fiscal year 1986. Two operating programs, the Reversed Field Pinch (RFP) and one version of the compact toroid called the field-reversed configuration (FRC), have met the previously established objectives for their development, and experiments are now being fabricated for the next crucial tests of confinement issues. The increment in funding is to continue this fabrication.

	FY 1985	FY 1986	FY 1987 Request
Research Operations................	$21,501	$14,413	$12,465

The shift in emphasis in the Advanced Fusion Concepts category is indicated in the budget requests for the past two years. The decrement in Research Operations in fiscal year 1986 was needed to shift funds into the Major Device Fabrication (MDF) subcategory. Research operations in the RFP and compact toroid areas were reduced as a result. During this fiscal year, a further funding shift is needed to meet the increased requirements in the MDF subcategory. A spheromak at the University of Maryland will begin experimental operation under this funding. This device has a 25 kilogauss magnetic field strength, the highest of any spheromak. This should allow testing of plasma heating and energy confinement during FY 1987. The University of Wisconsin RFP device began operations in 1986 and will continue to investigate crucial issues of physics and stability in a unique low cost experiment. While it does not extend plasma conditions beyond present levels achievable in other RFP devices, it will be used to study improvements in the RFP geometry, and it complements the MDF experiment in this concept. Several university experimental efforts are continuing to investigate crucial issues with unique, low cost facilities.

Major Device Fabrication...........	0	4,495	9,025

Two projects were initiated in the fiscal year 1986 budget. The first project is an RFP device whose performance objectives included a plasma current capability of 4 million amperes. This device is predicted to increase the confinement parameter by three orders of magnitude beyond existing devices and reach ion temperatures of 4 keV. It is to be completed in 1990, replacing the ZT-40 RFP device at LANL. The second project, an FRC device, whose objectives include the investigation of crucial physics issues of transport and stabilization in a small, high beta plasma. It will be completed in 1989, replacing the TRX-2 device at Spectra Technology.

These two projects will enable the fusion program to investigate the confinement physics of compact, high beta toroidal configurations.

	FY 1985	FY 1986	FY 1987 Request
Supporting Studies.................	$ 964	$ 650	$ 420

Exploratory experimental tests at modest levels of funding are carried out on two confinement approaches, the heliac and the dense Z-pinch. These supporting studies are characterized by either high beta or high power density concepts that may have the potential for very attractive reactor embodiments.

(2) Fusion Theory..........................	22,644	19,046	17,500

The fusion plasma theory category is responsible for the formulation and development of theories and models that explain the behavior of plasmas in fusion devices. A budget of $17,500,000 is requested to support these activities in FY 1987. In FY 1987, continued emphasis will be placed on theoretical studies to develop improvements in design and performance of toroidal concepts. Both analytical and computer models will be developed and applied. In addition, support will be provided for the modeling and interpretation of transport, confinement and auxiliary heating in the Advanced Toroidal Facility, a medium-sized stellarator experiment at ORNL, described in the Confinement Systems section. Further development of multi-dimensional simulation codes will also be supported. Models of burning plasmas will be refined in support of ignition and the burning plasma issue.

Slightly increased funding for toroidal theory will be used to strengthen the efforts in developing transport models and to study the effects of electric fields on confinement. Theoretical support of major toroidal experiments will be provided by task groups consisting of laboratory and university theorists. Further consolidation in the activities of national laboratory groups and large universities will be undertaken.

Mirror theory support will be decreased. Some theorists formerly associated with mirror theory will be redirected to work on toroidal or generic theories to support the overall program.

Funding for alternate concept theory will be decreased to reflect the decrease in research operations. Existing theories will be applied to understand the next generation of higher current, higher temperature alternate concept devices, as well as to develop and exploit uniform theoretical models which are applicable to both alternate concepts and principal concepts, such as tokamaks and stellarators.

Generic theory support will also be decreased. The requested funds will be used to support development of methods to treat non-linear problems and plasma turbulence. The Institute for Fusion Studies will be maintained at previous levels while support for atomic theory will increase slightly. The funds will cover developments in the theory of atomic processes (i.e., collisions and ionization) in plasmas, with emphasis on high temperature conditions.

	FY 1985	FY 1986	FY 1987 Request
(3) Experimental Plasma Research.........	$16,024	$14,866	$13,215

The experimental plasma research category contributes to the understanding of fusion plasma properties through basic research and develops innovative ideas for modifications to the tokamak concept through small scale research. The activities supported are diverse, ranging from research in atomic and plasma physics to testing of specific plasma configurations and diagnostic techniques. The experimental research activities are coordinated with the major plasma confinement tests carried out in the Confinement Systems subprogram. Research is supported primarily at universities, with a few activities carried out at national laboratories and industrial sites.

Of the requested $13,215,000 in operating funds, $8,875,000 will support plasma physics research. About $3,700,000 of these funds will be directed to new tests of ideas being advanced for tokamak improvement. These experiments will test modified plasma configurations and new techniques for driving the current required in the tokamak plasma. These innovation experiments were initiated in FY 1986 with emphasis on ideas that can be viably tested on a small scale and that extrapolate to definite performance improvements. The remaining plasma research funds ($5,515,000) support basic research (for example, on particle and heat loss mechanisms) on innovative ideas which can be pursued in existing facilities (for example, electron cyclotron heating for prevention of plasma disruptions on the Texas Experimental Tokamak).

About $3,140,000 of these funds support development of new or improved diagnostic techniques. Improved diagnostics are needed for spatial and temporal resolution of plasma temperature, density, and internal magnetic and electric fields. Such improved diagnostics are developed primarily through atomic beam and laser systems. New diagnostics are needed to measure properties of the nuclear reactions and resulting heating in burning plasmas. These burning plasma diagnostics may detect nuclear products outside the plasma (neutrons and gamma rays) and must also measure properties of the fast alpha particles within the plasma. In all cases these funds support only conceptual development and first tests of diagnostic systems. The diagnostic system tests may utilize small laboratory plasmas, the TEXT user facility, or, if required, major plasma devices within the Confinement Systems program.

About $1,200,000 of these funds are for understanding basic atomic physics processes that control plasma behavior and that can be exploited for plasma diagnostic purposes. This research uses plasma devices such as the TEXT tokamak, and other facilities such as low energy ion beams, accelerators, and laser driven light sources. In FY 1987 this effort will be directed at improved understanding of collisions between electrons and impurity ions. Detailed experiments on electron-ion collisions have just recently become possible and require revisions of previously used calculations.

	FY 1985	FY 1986	FY 1987 Request
(4) National MFE Computer Network........	$17,804	$16,222	$18,085

The National Magnetic Fusion Energy Computer Network provides large- and medium-scale scientific computing facilities for the entire magnetic fusion energy program. The center and the network have continued to play a crucial role in the development of the fusion program in the United States. The network provides access for the entire fusion community, both theoretical and experimental, to first-class computing, data analysis and modeling facilities. The network and the center have served as a model for many National Science Foundation projects to provide supercomputer access for university researchers.

The National Magnetic Fusion Energy Computer Network consists of the Magnetic Fusion Energy Computer Center (MFECC) located at Lawrence Livermore National Laboratory in Livermore, California, and a number of smaller scientific computers at other locations connected by a communications network which includes satellite links and leased land lines. This network provides the flexibility to match the communications power at a site to the load at that site, thus avoiding bottlenecks and unnecessary costs. To service the computing needs of the magnetic fusion program the MFECC includes a Cray 1, a Cray 1S, and a Cray 2. The Cray 2 computer is over four times as powerful as the Cray 1S and has significantly ameliorated the capacity problems at the MFECC. In addition, the Cray 2 has an extremely large memory which makes feasible more realistic three-dimensional computations than possible on earlier machines. Indeed, within the first three months after installation of the Cray 2, problems had been solved which were not possible on earlier computers.

This budget requests an increase of $1,863,000 over the FY 1986 budget. These funds will be used to restore the User Service Centers to a level at which they can effectively support their local users, to cover cost of living increases at the NMFECC and to initiate a lease to ownership of additional disk storage which is required to support the mature usage of the Cray 2 computer.

B. Capital Equipment...........................	3,170	5,619	4,600

An equipment budget of $3,000,000 is requested in support of the RFP MDF project. The funds will be used in partial payment for acquisition of the power supply system including a motor-generator flywheel, power converters and space preparation.

The research operations subcategory of the Advanced Fusion Concepts budget includes $700,000 for general laboratory and data acquisition equipment for experiments at the national laboratories.

$100,000 of capital equipment funds are to be used in the new tokamak improvement tests. $485,000 is to be used for general research equipment, primarily in diagnostic development ($250,000) and at TEXT ($100,000).

The sum of $215,000 is requested to procure replacement parts and some of the equipment required to maintain the network and the User Service Centers.

	FY 1985	FY 1986	FY 1987 Request
II. Confinement Systems...........................	$221,795	$203,179	$184,600
A. Operating Expenses........................	206,395	188,650	177,500

The Confinement Systems subprogram supports the Magnetic Fusion program's goal by working on two of the four key technical issues--the development of magnetic confinement systems, and the exploration of the scientific principles governing the behavior of burning plasma. The Confinement Systems subprogram contributes to the resolution of the former issue by conducting experiments to develop a scientific understanding of high temperature, collisionless plasmas. It contributes to the latter issue by operating the state-of-the-art research devices needed to identify the conditions required for ignition and to prepare for a burning plasma experiment.

The tokamak, the stellarator, and the tandem mirror magnetic confinement concepts have progressed to the stage of medium to high temperature tests of plasma physics principles. Of these, the tokamak and stellarator are closely related toroidal systems. The tandem mirror is a linear system. Although the confinement physics of these two classes of confinement systems is different, many of the basic plasma phenomena have common elements. In addition, many theoretical and experimental techniques and much technology are applicable to both. Both toroidal and linear magnetic confinement systems are making good technical progress. However, to accommodate present fiscal constraints, further research on tandem mirrors is being deferred in order to maintain a strong, focused toroidal program.

The Confinement Systems subprogram will resolve the first key technical issue by investigating the physics of toroidal systems in order to gain the predictive scientific understanding that will make the choice of an attractive confinement configuration possible. Since the tokamak concept has advanced to the point where it can serve as the vehicle for the exploration of the scientific principles governing the behavior of a burning plasma. The study of high temperature tokamak plasmas provides the scientific basis for resolution of the second key technical issues as well.

(1) Toroidal Confinement Systems.........	151,410	141,502	151,800

The Toroidal Confinement Systems' subelement has the responsibility for research on toroidal configurations operating with fusion relevant plasma conditions. The budget request of $151,800,000 is $10,298,000 above the FY 1986 level and includes an increased effort on TFTR and the Advanced Toroidal program. The research program for toroidal configurations is planned to resolve a discrete set of basic scientific issues. These issues are investigated through experiments on several devices. Each device is designed to address one or more of these basic scientific issues.

Historically, the tokamak was the first magnetic configuration device to demonstrate good confinement of hot, dense plasmas in a moderate sized device. The demonstration was significant enough to indicate that the tokamak had the potential to become a practical fusion reactor. The progress in the last 11 years has supported this initial indication. Because of this high level of performance in confining hot, dense plasmas, the tokamak has become the first choice of the international fusion community for studying the scientific issues associated with high temperature plasmas. It is also the leading candidate for a reactor confinement concept. In FY 1986, tokamaks in the U.S., Japan, and the European communities will all be operating with plasma confinement very near to reactor requirements. Furthermore, in FY 1986 the auxiliary heating of TFTR will be advanced to the point where equivalent energy breakeven experiments in a deuterium plasma will begin. This breakeven condition occurs when the calculated fusion power output from a D-T plasma equals the heating power input. This is expected to be achieved in 1987 on the TFTR experiment.

The underlying physics in all toroidal configurations is similar enough that advances made on one configuration can contribute to the improvement of another. The stellarator, in particular, has made outstanding progress in Japan and West Germany partly because they have been able to use the physics results from the tokamak. The Reversed Field Pinch (RFP), discussed in the Applied Plasma Physics subprogram, has evolved rapidly because of the infusion of tokamak-developed diagnostics, technology and theory. The spheromak (a close relative of the tokamak which is also discussed in the Applied Plasma Physics subprogram), was discovered by scientists associated with the tokamak program and is now under active experimental study. Each of these research efforts contributes to the understanding required for the development of a practical fusion reactor.

The potential of the tokamak concept continues to be enhanced by proposed modifications which would provide substantial performance gains. Tokamak improvements are being investigated on the Princeton Beta Experiment (PBX) and by proposed advanced configurations under study at the Oak Ridge National Laboratory (ORNL), GA Technologies (GA), and the Massachusetts Institute of Technology (MIT).

The search for improving the toroidal configuration by the addition of helical fields, as in the stellarator, is supported by the Advanced Toroidal Facility (ATF) at Oak Ridge National Laboratory and by a program of international collaboration. The U.S., Japan, West Germany, and Spain collaborate very closely on medium sized stellarator experiments, thereby, making it possible to explore a significant portion of the large range of physics parameters that the stellarator can produce.

Scientific issues associated with a burning plasma are being addressed by the coordinated programs of confinement experiments in several countries. The key U.S. experiment is TFTR, which is providing the initial size and plasma parameter scaling information that is needed for the design of a burning plasma experiment. Subsequent information on auxiliary heating techniques and impurity control that will be valuable in the design of a burning plasma experiment is being obtained from the Joint European Torus (JET) and the Japanese JT-60 tokamak through a program of international collaboration on large tokamaks. In FY 1987, under a U.S./Japan agreement, the D-III-D experiment will begin substantive experiments in a D-shaped tokamak plasma to investigate stable operation with better magnetic field utilization (beta). This is a key issue in the size and cost of a burning plasma experiment. Also of interest for burning plasma experiments is the physics of ash removal and impurity control which is being studied through international collaborations on the TEXTOR (West Germany), ASDEX-Upgrade (West Germany), and TORE-SUPRA (France) tokamaks.

The following is a summary of the budget request for the four Toroidal Confinement Systems operating categories:

	FY 1985	FY 1986	FY 1987 Request
Tokamak Fusion Test Reactor........	$74,256	$67,974	$78,400

This budget will support the operation of TFTR, including the preparation for using ion cyclotron radio frequency heating to broaden the range of plasma parameters the machine can produce. It will continue preparation for FY 1989 tritium operations. In FY 1987 TFTR will have all of its subsystems operating at full capabilities, including the reliable operation of the long pulse neutral beam ion sources. The near term objectives of the TFTR program are to study the basic properties of high temperature, high density hydrogen and deuterium plasmas. In FY 1987, TFTR is expected to achieve plasma breakeven conditions, the condition under which a D-T plasma would generate power equal to the auxiliary input power. Understanding the fundamental mechanisms governing the behavior of plasmas at breakeven conditions (high temperatures and high densities) will be of vital importance in designing a successful burning plasma experiment or a future toroidal device. In FY 1987 and FY 1988, TFTR, in conjunction with the other large tokamak experiments in the world, will provide a valuable opportunity to probe the physics of well confined, high temperature plasmas. Following the successful operation at the breakeven level through FY 1988, TFTR is scheduled to perform deuterium-tritium experiments in FY 1989. In these experiments, TFTR is expected to make possible the first investigations of the effects of alpha particles on toroidal plasma confinement and stability.

At MIT, following the completion of experiments on the Alcator C device, a team of physicists will collaborate on the TFTR experiment. In FY 1987, TFTR will be producing copious amounts of experimental data, and the additional scientists from MIT will expedite the analysis of this data and enhance the efficiency of the TFTR program.

Base Toroidal Program..............	49,690	46,885	38,700

The base toroidal program provides support for experimental research and operation of the conventional tokamak confinement experiments for the development of improved operational tools and techniques. This includes the Doublet III-D and support of several collaborative efforts on foreign experimental machines. In FY 1987 at GA Technologies, Inc., this budget will support the operation of D-III-D to extend the experimental operating parameters of this facility. The major objective will be to explore the limits of high beta operation. Limited to hydrogen operation, at the high energy densities planned, Doublet III-D will produce fusion relevant plasma parameters to provide information on the physics of burning plasmas. The physics effort on D-III-D will be strengthened in FY 1987 by collaboration with a team of physicists from the LLNL following the completion of the TMX Upgrade experiments.

The D-III-D facility is also an important part of the U.S.-Japan international collaboration for research on fusion energy development. A collaboration agreement between the Japan Atomic Energy Research Institute (JAERI) and the Department of Energy (DOE) to conduct a joint research program on D-III-D will continue through FY 1988. Japanese scientists will participate directly in the Doublet III-D research program.

The FY 1987 plans for the Base Toroidal Program reflect a growing commitment to international collaboration, especially in the areas of plasma fueling, particle control, rf heating, and steady-state operation in toroidal configurations. The European and Japanese programs have tokamaks that are either operational or are in the process of being installed which have long pulse heating and plasma control systems that make them attractive for the investigations of these issues. Design, operation, and understanding of either a short pulse ignited plasma or a long pulse experimental test reactor will benefit from an increased understanding of impurity control and particle handling issues. These devices include TEXTOR and ASDEX-Upgrade in the Federal Republic of Germany, TORE SUPRA in France, and JET in England. Scientists from PPPL, MIT, ORNL, GA, Sandia and University of California, Los Angeles (UCLA) will participate in these international activities.

	FY 1985	FY 1986	FY 1987 Request
Advanced Toroidal Program..........	$15,239	$12,148	$27,161

The Advanced Toroidal Program supports experiments designed to study improvements to the conventional toroidal configuration. This includes the first full year of operation of the Advanced Toroidal Facility and the Princeton Beta Experiment. The emphasis of the Advanced Toroidal Facility (ATF) at Oak Ridge National Laboratory will be on understanding the physics of toroidal systems that use external helical windings (stellarators) rather than a current flowing in the plasma to create the confining magnetic field. ATF is designed to create a wide range of magnetic confinement geometries which are complementary to stellarator experiments in Germany and Japan. The main objective is to determine the maximum beta that can be obtained. Demonstrating that a high beta stellarator geometry exists would be significant because the stellarator is intrinsically a steady state toroidal fusion configuration.

At PPPL, this budget will support the initial operation of the Princeton Beta Experiment Upgrade (PBX-U). The PBX has demonstrated the highest beta achieved yet in a tokamak using a shaped plasma configuration. An upgrade of this device will be carried out in FY 1986-1987. This will allow the exploration of the regimes that theoretically allow even higher beta operation. Achievement of these high values of beta could lead to a significant improvement in the performance of the tokamak concept. This, in turn, could lead to a high power density tokamak reactor core. This budget will also support advanced physics studies of compact, high field ignition devices at PPPL, further tokamak modeling studies at PPPL, advanced toroidal studies at MIT, and initial physics studies of engineering test reactor concepts at LLNL of an international fusion facility in support of the President's initiative.

	FY 1985	FY 1986	FY 1987 Request
Major Device Fabrication...........	$12,225	$14,495	$7,539

This budget will support the modification and upgrade of existing devices to enhance their capabilities to further research in areas suggested by theory and previous experiments.

At PPPL, the upgrading of PBX to PBX-U, which begins in FY 1986, will be completed in FY 1987.

The ATF facility at ORNL will be completed in the first quarter of FY 1987. At GA, procurement of the long pulse ion sources will be completed. Beamline modifications to accommodate the new sources will be completed in FY 1988.

	FY 1985	FY 1986	FY 1987 Request
(2) Mirror Confinement Systems...........	54,986	47,148	25,700

The linear tandem mirror represents one of the two basic magnetic confinement configurations which has been shown to confine plasmas of fusion interest. The next appropriate step for the tandem mirror program would be the preparation for operation of the large scaling experiment, MFTF-B. However, recognition that the increasing stringencies in the federal budget will not support the originally planned operating costs for MFTF-B has led to a decision to focus the U.S. fusion effort on the toroidal program. As a result, the MFTF-B facility will be mothballed. Since there is mirror research abroad, an appropriate step is to work toward an international consensus on the best use of the MFTF-B facility in the overall world program. Future operation of the facility in an international context might be one outcome of such a planning activity. By early FY 1987, the fundamental physics of tandem mirrors will have been tested on TMX-U and TARA and work on these two devices will be completed. Most of the specialized personnel and material resources of these programs will then be applied to supporting the toroidal confinement systems. During the remainder of FY 1987 only the small exploratory Phaedrus device at the University of Wisconsin will be operated in the U.S. Collaboration with the Japanese mirror program will be continued in FY 1987.

	FY 1985	FY 1986	FY 1987 Request
Tandem Mirror Research Operations..	32,998	31,753	10,700

Of the requested funds, an amount of $1,600,000 will be used for the last year of Phaedrus operation and to continue the collaboration with the Japanese at a level of $600,000. The remainder ($8,500,000) will be used to bring the TMX-U and TARA experiments to a logical conclusion. Future operation of MFTF-B will await the availability of funds and possible international collaboration.

	FY 1985	FY 1986	FY 1987 Request
EBT Research Operations............	$ 988	$ 0	$ 0

Research operation support on the EBT concept was terminated in FY 1985.

Mirror Fusion Test Facility-B......	20,999	15,395	15,000

The funding requested for FY 1987 provides for closeout of current fabrication activities and mothballing of the MFTF-B device. Future operation of this facility will await the availability of funds and possible international collaboration.

B. Capital Equipment..........................	15,400	14,529	7,100
(1) Toroidal Confinement Systems.........	10,450	10,488	7,100

The budget request of $7,100,000 for capital equipment funds provides for ongoing requirements for power supplies, diagnostic instruments, vacuum systems, data acquisition and analysis systems, and miscellaneous test and analysis equipment.

Of the total capital equipment funds, $3,500,000 is requested for TFTR at PPPL for a robotic maintenance manipulator required for limited D-T operation, diagnostic instrumentation, shielding blocks for diagnostics, vacuum systems, and data acquisition equipment including mass storage devices; $1,600,000 is requested for D-III-D at GA Technologies, Inc. for power system switches, a data analysis computer, diagnostic equipment, data acquisition and control hardware, and cryogenic systems; $1,500,000 is requested for ATF at ORNL for vacuum pumps and valves, data acquisition equipment, and diagnostics instrumentation including spectrometers, lasers, and infrared detectors; and $500,000 is requested for PBX at PPPL for electronic components, vacuum systems, and diagnostics hardware.

(2) Mirror Confinement Systems...........	4,950	4,041	0

No funds are requested for FY 1987.

. Development and Technology....................	73,000	61,389	52,400

This subprogram provides for the development of the technologies needed for fusion experiments and for design and analysis of fusion systems. Elements in this subprogram support research on all four major technical issues in the development of magnetic fusion: the development of magnetic confinement systems, the physics of burning plasmas experiment, the development of nuclear technology and the development of fusion materials.

Recent progress in the Development and Technology subprogram area has included tests of three large superconducting magnets in the International Fusion Superconducting Magnet Test Facility (IFSMTF); operation of a multi-pellet pneumatic fuel injector on TFTR; successful demonstration of the long pulse neutral beam development source; development of new concepts for compact, high power R.F. launchers for plasma heating; increased confidence in vanadium as a reduced activation material; first results of steady-state erosion and deposition materials changes using the Plasma Interactive Surface and Components Experimental System (PISCES); design studies of inexpensive copper magnet ignition devices; and definition of nuclear technology testing needs from the Finesse study.

The Development and Technology budget decreases by $8,989,000 in FY 1987. Program efforts are focused on the most critical technology issues. Programs in the areas of Plasma Technologies and Fusion Technologies are important to the successful performance of fusion scientific experiments and are key to understanding the potential of fusion systems to provide energy. Fusion Systems Analysis will continue the exploration of small copper magnet machine designs for ignition experiments and studies in support of the President's international fusion initiative. Existing international cooperative commitments will be fully met.

	FY 1985	FY 1986	FY 1987 Request
A. Operating Expenses........................	$67,900	$57,059	$50,510
(1) Plasma Technologies..................	28,446	22,612	19,720

The FY 1987 budget for Plasma Technologies will continue to support programs that address the key technology issues associated with the components and systems which are used to magnetically confine and sustain high temperature fusion plasmas, but the breadth and depth will necessarily be reduced. The programs include the technologies involved in magnetics, plasma heating, and plasma fueling. The magnetics effort develops the technologies that will enable construction of reliable, cost-effective superconducting and copper magnets for producing the high magnetic fields required to hold and confine hot fusion plasmas. The plasma heating and fueling efforts develop the technologies and components to heat and sustain plasmas for current and future fusion experiments.

The Plasma Technologies development efforts have been extremely productive, resulting in significant technology spinoffs that have reached the commercial state. The Plasma Technologies programs also provide very fertile ground for effective, cost saving international efforts. The IEA Large Coil Task, a major international effort on manufacturing and testing large superconducting magnets continues. Substantial cooperative efforts are also underway in high field superconductors, low temperature materials testing, neutral beam and RF heating technology, and pellet fueling.

Magnetic Systems

The budget request for Magnetics Systems is $10,270,000. Overall, the magnetics effort is lower than FY 1986 because the completion of the last U.S. 8 Tesla large coil in FY 1985 and the coil contract closeout and a one-time State tax payment in FY 1986. In FY 1987, testing of the six-coil array in the International Fusion Superconducting Magnet Test Facility (IFSMTF) will continue from its initiation in FY 1986 and will require a threshold support level to meet our international obligations to operate the IFSMTF until the test objectives have been successfully achieved. A minimum capability will be maintained on the superconducting technology effort since the availability of cost effective magnet designs, either for superconducting or normal systems is a prerequisite in decisions that will have to be made for the design and construction of any next step fusion device.

Heating and Fueling

The budget request for Plasma Heating and Fueling techniques is $9,450,000. The continued progress in experimental fusion plasma physics is directly attributable to the availability of equipment developed in plasma heating and fueling activities during the past several years. Experimentation in higher density and temperature regimes will necessitate higher power and possibly higher frequency electromagnetic wave sources, transmission components, and improved pellet fueling devices. For FY 1987, this budget will maintain essential efforts in these activities, but the remaining neutral beam development efforts will be phased out.

The positive ion neutral beam effort will be reduced to a level that provides support to operating experiments. The negative ion beam effort will be phased out and fusion will rely on the Space Defense Initiative (SDI) to cover this technology development since it is not needed for fusion development in the near term.

Development of radio frequency heating technology will continue with completion of tests on the Radio Frequency Test Facility (RFTF) of the compact, high power launcher and initiation of tests on Doublet-III/TFTR or Tore Supra. Development will focus on those wave launcher types that show the most promise for reliable long pulse operation in high temperature burning plasmas.

Electron Cyclotron Heating (ECH) of plasmas increases the stability of neutral beam and RF heated plasmas. The prime component of ECH systems is the gyrotron in which U.S. industry is the world leader in development and manufacture. Efforts in FY 1987 will be directed at innovative approaches to developing higher power, higher frequency versions of the gyrotron.

The plasma fueling effort is directed towards developing a tritium pellet injector which can produce pellets with a speed greater than the 1 to 2 kilometers/second achieved by the multiple shot injector for TFTR which will be placed in operation in FY 1986. The use of pellet injectors developed in the program during the past two years has enabled the exploration of high density plasmas in several devices and has resulted in stronger world-wide collaboration in fusion research.

	FY 1985	FY 1986	FY 1987 Request
(2) Fusion Technologies..................	$25,414	$22,785	$20,790

The objective of the Fusion Technologies category is to address the critical technology issues concerned with the effects on systems in contact with the plasma and to the neutrons produced by the plasma.

In FY 1987, the requested budget for Fusion Technologies will support three major sub-areas: (1) Fusion Nuclear Technology, (2) Fusion Materials, and (3) Environment and Safety.

The budget requested in FY 1987 will support the overall fusion technologies effort in selected areas consistent with the Magnetic Fusion Program Plan.

Fusion Nuclear Technology

The fusion nuclear technology budget request is $5,665,000. The objective of the Fusion Nuclear Technology element is to develop the major nuclear technologies needed for practical application of fusion energy. Fusion nuclear technology development is one of the key technical issues facing the magnetic fusion program. It addresses fusion systems which must deal with the effects of neutrons, electromagnetic radiation, and a radioactive environment created by fusion devices. The nuclear technology element include nuclear analysis methods, blankets, and tritium processing and control systems.

Activities in blankets will be limited to the most critical feasibility issues associated with the ability of blankets to perform their multiple functions of heat extraction, tritium production, and radiation shielding. In FY 1987, the most critical issue for liquid metal cooled blanket concepts, the effects of magnetic fields on coolant pressures and flows, will be studied experimentally. Major questions about the recovery of tritium from solid breeder materials will be addressed by tests in fission reactors.

Activities in tritium processing and control systems will address the fusion safety requirements for reliably processing, containing, and cleaning potential leakages of tritium generated in the blankets. In FY 1986, individual subsystems of the Tritium Systems Test Assembly (TSTA) at Los Alamos will be tested in preparation for limited full loop operation of TSTA in FY 1987.

An integral part of the Fusion Nuclear Technology element is a program which supports all of the above activities by providing the data bases and analytical methods needed to conduct the nuclear design and analysis of fusion devices. For example, a cooperative program with the Japanese that began in FY 1985 to develop methods for predicting the neutronics performance of tritium breeding materials in fusion reactors will be continued.

In FY 1987, focus will be on the detailed use of existing test facilities, the assessment of various fusion test facility options, and international collaboration in the development of test facilities for nuclear technology development.

Environment and Safety

The Environment and Safety budget request for FY 1987 is $1,400,000. This budget will support activities to develop an understanding of the environmental and safety concerns anticipated in present and future operational fusion facilities.

In the environmental area, work will continue to assess the environmental impacts of magnetic fusion energy devices. In the safety area, work will continue in the areas of tritium waste management, magnets, and the use of reduced activation materials to minimize environmental impacts of fusion.

Fusion Materials

The Fusion Materials budget request for FY 1987 is $13,725,000. The Plasma Materials and High Heat Flux programs provide for tritium permeation and inventory studies at Sandia National Laboratories (SNL), Livermore, CA, in support of the projected TFTR tritium program, full operation of the plasma/materials test facility at SNL, Albuquerque, NM, in support of TFTR coatings program and the upgraded RFP device, and continued operation of the PISCES facility at UCLA.

The program on radiation damage in materials will limit ongoing research on reduced activation materials. The scope of this program is limited to critical materials for fusion systems, including structural and blanket materials. Theory and modeling research in universities and laboratories will be strengthened.

The February 1982 U.S./Japan agreement on RTNS-II will be completed in FY 1987. Discussions will continue on Japanese support for program on high fluence materials radiation damage research in the HFIR fission reactors. Support will be maintained to complete modification of the HFIR fission reactor in order to reduce costs by the transfer of the experimental program from the ORR to HFIR.

	FY 1985	FY 1986	FY 1987 Request
(3) Fusion Systems Analysis..............	$14,040	$11,662	$10,000

The requested budget in this area will support system design studies of experimental machines with burning plasmas, an evaluation of innovative approaches to a test reactor, design concepts for advanced tokamak devices for electrical power production, and systems studies of reversed field pinch devices.

Studies of experimental devices that will be used to produce burning plasmas will be the primary focus of Fusion Systems Analysis in FY 1987. Studies of a tokamak with copper toroidal field coils for an ignition device will continue, based on work performed in FY 1986. The objective is to identify the most cost effective path to complete such an ignition experiment.

A second focus for the Fusion Systems Analysis area is design studies of an international fusion facility in support of the President's initiative for international collaboration in fusion. This request also supports the completion of a design study for a reversed field pinch device.

Support will continue for the International Tokamak Workshop (INTOR) being conducted by the International Atomic Energy Agency (IAEA) with the participation of the United States, the Soviet Union, European Community, and Japan.

	FY 1985	FY 1986	FY 1987 Request
B. Capital Equipment........................	$ 5,100	$ 4,330	$ 1,890

The FY 1987 requirements for capital equipment in the Development and Technology subprogram total $1,890,000, a decrease of $2,440,000 from the FY 1986 level, and are highlighted below:

(1) Plasma Technologies..................	3,386	2,309	680

The capital equipment request to support Plasma Technologies activities is $680,000, a reduction of $1,629,000 from FY 1986. Funds are requested to support the High Field Test Facility, the RF Test Facility, pellet injector development, RF development, and base technology efforts.

(2) Fusion Technologies..................	1,714	2,021	1,210

Capital equipment funds are requested to support the experimental research programs in materials, safety, and nuclear technology which include the Plasma Materials Test Facility (PMT), the Plasma Surface Interaction Experiment (PISCES), liquid metal test loop, tritium testing facilities, the Tritium Systems Test Assembly (TSTA), and for radiation facilities at the Oak Ridge Reactor as well as modification to the High Flux Isotope Reactor at Oak Ridge and for the Fast Flux Test Facility at Richland which are employed in the materials irradiation programs.

IV. Planning and Projects.........................	48,501	21,982	16,800
A. Operating Expenses.......................	12,201	5,528	4,780

A sum of $3,776,000 is requested to cover the program's legal obligation to support the Small Business Innovative Research (SBIR) program. The remainder is requested to support non-fusion landlord responsibilities for inventories at ORNL.

B. Capital Equipment........................	3,800	3,801	3,820

The FY 1987 request of $3,820,000 for capital equipment permits the purchase of general purpose equipment to support non-fusion specific landlord responsibilities at ORNL.

These funds will be used to replace obsolete or worn equipment as well as to provide new state-of-the-art equipment at the laboratory.

C. Construction.............................	32,500	12,653	8,200

The FY 1987 construction budget request of $8,200,000 is entirely for general plant projects. These funds will support projects at several laboratories to meet health, safety, and programmatic requirements and to provide for miscellaneous modifications, additions, alterations, replacements and non-major new construction items to meet programmatic goals. This will allow us to provide continuity of operation, improvement to economy, minor changes in operating methods and protection of the Government's investment by preventing excessive deterioration of facilities. Of the total funding requested, $7,200,000 is provided to ORNL, $500,000 to PPPL, $200,000 to LLNL, and $300,000 to LANL. It is noted that at ORNL the Magnetic Fusion Energy program has the responsibility to provide funding for all of the general purpose plant needs for this multipurpose laboratory.

	FY 1985	FY 1986	FY 1987 Request
V. Program Direction............................	$ 4,150	$ 3,608	$ 4,000
Total FTE's....................................	66	62	62

The FY 1987 request for Magnetic Fusion Energy Program Direction is $4,000,000. These funds are required to provide for personnel and other costs associated with continuation of 62 full-time equivalents.

The manpower base supported under this account provides the technical management expertise needed to direct and administer the highly scientific and technical research and development program in fusion energy. 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, as well as construction projects; interagency and international liaison; and related administrative and program support activities.

Management improvements, such as increased use of office automation, assignment of some specific responsibilities to field offices and major mission assignments to laboratories, have been implemented in recent years to assist with certain workload requirements involved in managing this highly technical program. The recent shift in emphasis from construction to operation of fusion research test facilities has created increased workload in managing these facilities. Increased planning and both interlaboratory and international coordination are required to achieve effective utilization of existing major facilities and funding resources in addressing major technical and engineering issues. Updating the overall program plan and individual subprogram plans to reflect a significant redirection of effort in physics research and technology development is continuing. Support of the design and conceptual work on an ignition experiment and on the advanced concept initiatives begun in FY 1986 will continue.

The program is increasingly involved in international collaboration. This has expanded from a scientific exchange program with the Soviets to include major hardware cooperation programs with Japan and the European Community involving tens of millions of dollars annually and hundreds of scientists. Evaluation of current international activities is required to take advantage of opportunities for new cooperative programs and to avoid duplicative work. The Office of Fusion Energy staff must assure that both the content and the balance of the exchange programs are appropriate. Negotiations, intragovernmental liaison, and participation in international working groups dealing with both technical and managerial aspects of projects are very demanding of staff time.

DEPARTMENT OF ENERGY
1987 CONGRESSIONAL BUDGET REQUEST
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.)

Advanced Toroidal Facility (ATF)
Oak Ridge National Laboratory

Total Estimated Cost (TEC): $19,900,000
(For Design and Construction)

Advanced Toroidal Facility (ATF)
Oak Ridge National Laboratory

Total Estimated Cost (TEC): $19,900,000

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

	Cumulative Prior Years	FY 1985 Actual		FY 1986 Estimate		FY 1987 Estimate		Total Project Funding
	Obs.	B/A	B/O	B/A	B/O	B/A	B/O	B/A
Fabrication								
Operating Expenses (DOE):								
Design and Construction	$ 8,025	$ 6,425	$ 6,768	$ 4,744	$10,389	$ 706	$ 863	$19,900
Subtotal	8,025	6,425	6,768	4,744	10,389	706	863	19,900
Related Funding Requirement								
Capital Equipment	950	218	66	0	0	0	0	1,168
Research Operations	2,365	626	802	155	221	0	0	3,146
Subtotal	3,315	844	868	155	221	0	0	4,314
Total Project	$11,340	$ 7,269	$ 7,636	$ 4,899	$10,610	$ 706	$ 863	$24,214

Description Objective and Justification

The existing ISX-B tokamak facility is being modified to test the physics of steady-state, high beta toroidal configurations, which potentially could provide significant advantages for proposed toroidal fusion reactors. The modified device, ATF, is intended to test beta limits and collisionless transport in a current-free steady-state stellarator/torsatron configuration.

Recent experimental results obtained in stellarators/torsatrons in Japan and Germany have renewed interest in the U.S. in utilization of helical windings to achieve steady-state operation of toroidal fusion reactors. The present stellarator devices are, however, relatively small with limited confinement capability. ATF is intended to test stellarator confinement and beta limits at a level comparable with tokamaks such as ISX-B and PLT. It will be the only major U.S. facility in the next few years to carry out experiments on stellarators.

Advanced Toroidal Facility (ATF)
Oak Ridge National Laboratory

Total Estimated Cost (TEC): $19,900,000

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

Description, Objective and Justification (continued)

The basic ATF device consists of a helical stellarator coil set, three vertical field coils, an ohmic heating system, and a vacuum vessel. Magnetic configuration flexibility, large cross section and good access are important design considerations. It will utilize a significant part of the existing ISX-B facilities, including power supplies, neutral beam systems, instrumentation and control systems, utilities, diagnostics, etc.

The conceptual design was conducted in FY 1983. The period from FY 1983 through FY 1986, inclusive, will be used for design (Title I and II Engineering) acceptance testing, procurement of the necessary hardware, and installation of the hardware.

(a) Schedule of Planned Activities

Activity	Start	Complete
Conceptual Design	4Q FY 1982	2Q FY 1983
Procurement	4Q FY 1983	4Q FY 1985
Final Design	4Q FY 1983	2Q FY 1986
Fabrication	3Q FY 1984	4Q FY 1986
Assembly	2Q FY 1985	1Q FY 1987
Startup	1Q FY 1987	

(b) Management and Contracting

A project manager was appointed using existing Martin Marietta Energy Systems, Inc. (MMES) procedures. Design was done by the MMES Engineering Division. Procurement will be through MMES's Purchasing Division using guidelines approved by DOE/ORO. Most items will be procured from outside vendors. A construction contractor will do site preparation and construction work using DOE/ORO guidelines.

(c) Prior Year Achievements

Title I and II design of all components including helical coils, vacuum vessel and structural shell are completed and contracts for procurements were placed. Prototype helical coil segment was fabricated and tested. The delivery of major components including helical field conductor and structural tee sets, structural shell segments, and vacuum vessel will be completed. Field assembly of the device will be initiated.

Total Estimated Cost (TEC): $19,900,000

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

(d) Current Year Achievements

The assembly of the facility and its commissioning will be completed.

(e) Reasons for Increases and Decreases

The increase in the TEC from $19,300,000 to 19,900,000 is due to the added scope to the project. A new set of mid-vertical field coils were added to improve the flexibility of the facility.

(f) Cost Estimate

Engineering, Design and Inspection	$ 4,740
Procurement and Construction Costs	14,091
Contingency	1,069
Total	$19,900

Escalation is included at 8.5% per year.

DEPARTMENT OF ENERGY
1987 CONGRESSIONAL BUDGET REQUEST
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): $8,000,000
(For Design and Construction)

FRC Physics Experiment
Spectra Technology*

Total Estimated Cost (TEC): $8,000,000

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

	FY 1986 Estimate		FY 1987 Estimate		FY 1988 Estimate		FY 1989 Estimate		Total Project Funding
	B/A	B/O	B/A	B/O	B/A	B/O	B/A	B/O	B/A
Fabrication									
Operating Expenses	$ 1,075	$ 1,075	$ 2,425	$ 2,425	$ 3,050	$ 3,050	$ 1,450	$ 1,450	$ 8,000
Subtotal	1,075	1,075	2,425	2,425	3,050	3,050	1,450	1,450	8,000
Related Funding Requirement									
Research Operations	1,120	1,120	1,475	1,475	1,055	1,055	500	500	4,150
Subtotal	1,120	1,120	1,475	1,475	1,055	1,055	500	500	4,150
Total Project	$ 2,195	$ 2,195	$ 3,900	$ 3,900	$ 4,105	$ 4,105	$ 1,950	$ 1,950	$12,150

Description, Objective and Justification:

The term field reversed configuration (FRC) refers to a special class of elongated toroidal plasma equilibria contained in a solenoidal magnetic field; the magnetic field is purely poloidal. 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.

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 64-cm-diam, 200-cm length, $3.5 \times 10^{15} cm^{-3}$ particle density, 350 eV temperature, energy confinement time of 2 milliseconds, and fusion Lawson parameter of 2×10^{12} sec-cm^{-3}.

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

FRC Physics Experiment
Spectra Technology

Total Estimated Cost (TEC): $8,000,000

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

(a) Schedule of Planned Activities

Activity	Start	Completion
Device Design	3Q FY 1986	2Q FY 1987
Fabrication and Installation	4Q FY 1986	2Q FY 1989
Begin Operations	3Q FY 1989	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

Technical proposal for project was reviewed and pre-conceptual design, project approach and program goals were accepted.

(d) Current Year Achievements

A contract will be negotiated and the project management team will be established. Final cost and schedule projections will be completed after a final project review is conducted in the first quarter of FY 1987.

(e) Reasons for Increases and Decreases

Total estimated cost (TEC) has been reduced from the $9,700,000 requested in the FY 1986 Congressional budget to the $8,000,000 contained herein. The device size and energy storage requirements have been reduced as a result of the technical review of the proposal.

FRC Physics Experiment
Spectra Technology

Total Estimated Cost (TEC): $8,000,000

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

(f) Cost Estimate (Cost estimate is preliminary)

Engineering and Design	$ 1,100
Procurement and Fabrication	4,000
Assembly and Installation	1,700
Contingency	1,200
Total	$ 8,000

Escalation is included at 5% per year.

124

DEPARTMENT OF ENERGY
1987 CONGRESSIONAL BUDGET REQUEST
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.)

Reversed Field Pinch
Los Alamos National Laboratory (LANL)

Total Estimated Cost: $32,300,000
(For Design and Construction)

Reversed Field Pinch
Los Alamos National Laboratory

Total Estimated Cost: $32,300,000

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

	FY 1986 Estimate		FY 1987 Estimate		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	$ 3,420	$ 3,220	$ 6,600	$ 6,400	$ 8,680	$ 8,680	$ 9,700	$ 9,700	$ 3,900	$ 4,300	$32,300
Subtotal	3,420	3,220	6,600	6,400	8,680	8,680	9,700	9,700	3,900	4,300	32,300
Related Funding Requirement											
Research Operations	915	915	1,400	1,400	485	485	0	0	0	0	2,800
Capital Equipment	3,647	3,647	3,000	3,000	2,153	2,153	2,400	2,400	6,200	6,200	17,400
Subtotal	4,562	4,562	4,400	4,400	2,638	2,638	2,400	2,400	6,200	6,200	20,200
Total Project	$ 7,982	$ 7,782	$11,000	$10,800	$11,318	$11,318	$12,100	$12,100	$10,100	$10,500	$52,500

Description, Objective and Justification

The presently operating reversed field pinch (RFP) devices have achieved outstanding experimental results which surpass design specifications for the devices. For example, in ZT-40M, experimental duration has reached 25 milliseconds exceeding the design goal of 2 millisecond. During the recent review of certain fusion development issues, the Magnetic Fusion Advisory Committee recommended proceeding with the physics exploration of the reversed field pinch concept. The importance of extending the current capability to values in the megampere range in order to test energy confinement was emphasized. As a result, a device will be fabricated which will have an initial current performance of 2 megamperes (MA) with subsequent increase to 4 MA. This will bring to the fusion program an experimental capability that increases first wall heat flux, provides information on tokamak-like operating modes, high magnetic field shear, physics of MHD beta limits, and MHD minimum energy states.

Reversed Field Pinch
Los Alamos National Laboratory

Total Estimated Cost: $32,300,000

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

Description, Objective and Justification (continued)

The device will consist of magnetic field coils, vacuum system, control system, and structural support systems. Related project funding will provide a power supply system from capital equipment funds and the required physics and engineering support from operating expense funds. The initial capability of the device will be 2 megamperes of current, but the device will be upgradable using additional power supply systems to achieve 4 MA. Technical goals will include minimization of magnetic field errors, design of plasma limiters for high heat flux, first-wall thermal loading (1.5 to 5 MW/m^2), and steady state operational capabilities.

The funding profile shown will allow fabrication to begin in FY 1986, and construction to be complete in CY 1989.

(a) Schedule of Planned Activities

Activity	Start	Complete
Device Design	1Q FY 1986	2Q FY 1987
Procurement	2Q FY 1986	1Q FY 1989
Fabrication and Installation	3Q FY 1986	1Q FY 1990
Plasma Operations	2Q FY 1990	Indefinite

(b) Management and Contracting

The Los Alamos National Laboratory (LANL) has been assigned responsibility for this project. The LANL management team is being organized and is expected to be complete by the third quarter of FY 1986. An objective of the RFP program is to involve other U.S. institutions that have skills needed for RFP development. To achieve this end, a competitive solicitation is to be accomplished during FY 1986. This solicitation will seek to attract parties interested in a cost shared joint participation in this project. Representatives from such a participant shall be expected to participate fully in the project management.

(c) Prior Year Achievements

Technical proposal for the project was reviewed, and pre-conceptual design, project technical approach and program goals were established. This included the recommendation to incorporate certain changes in the initial hardware that make it capable of 4MA operations. This includes the immediate acquisition of a single motor-generator adequate for the ultimate capability.

Total Estimated Cost: $32,300,000

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

(d) Current Year Achievements

A contractor and site has been selected and the project management team is being organized. The Los Alamos National Laboratory has been assigned responsibility for this project. It will be sited in the target chamber hall of the Antares facility at LANL. Final cost and schedule projections will be completed during the third quarter of FY 1986.

(e) Reasons for Increases and Decreases

The decision to provide partially for the 4 megampere plasma current capability resulted from an examination of the world-wide reversed field pinch program and the guidance provided during the FY 1986 appropriation process. This decision affects only slightly the cost and schedule to achieve the 2 megampere operation described in the FY 1986 budget submission. The full 4 megampere current capability will be provided by the fourth quarter of FY 1991. The procurement items called for in FY 1990 are predominantly additional power conversion equipment needed for the higher current capability.

(f) Cost Estimate (Cost estimate is preliminary)

Engineering and Design	$ 5,100
Procurement and Fabrication	20,400
Assembly and Installation	4,600
Contingency	2,200
Total	$32,300

Escalation is included at 5% per year.

DEPARTMENT OF ENERGY
1987 CONGRESSIONAL BUDGET REQUEST
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.)

DIII-D Extended Pulse Neutral Beams
GA Technologies, Inc.

Total Estimated Cost: (TEC) $7,400,000
(For Design and Construction)

DIII-D Extended Pulse Neutral Beams
GA Technologies, Inc.*

Total Estimated Cost (TEC): $7,400,000

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

	Cumulative Prior Years	FY 1986 Estimate		FY 1987 Estimate		FY 1988 Estimate		Total Project Funding
	Obs.	B/A	B/O	B/A	B/O	B/A	B/O	B/A
Fabrication:								
Operating Expenses	$ 0	$ 2,371	$ 2,371	$ 3,000	$ 3,000	$ 2,029	$ 2,029	$ 7,400
Subtotal	0	2,371	2,371	3,000	3,000	2,029	2,029	7,400
Total Project	$ 0	$ 2,371	$ 2,371	$ 3,000	$ 3,000	$ 2,029	$ 2,029	$ 7,400

Description, Objective and Justification

The Doublet III facility with the new Dee-shaped vacuum vessel installed (DIII-D) will be the U.S. fusion program's most flexible tokamak facility with a performance capability in hydrogen approaching that of TFTR and JET. DIII-D will operate at lower magnetic field than TFTR, but with a plasma shaping capability that is more flexible than that of JET. The toroidal program plans to rely heavily on DIII-D through the 1980's to provide the information necessary to understand the physics of shaped plasmas with parameters approaching those of fusion plasmas. To fulfill its role in the toroidal program it will be necessary for the DIII-D facility to extend its pulse length to several seconds. Longer pulse heating is required to bring the larger DIII-D plasma to equilibrium and then to study the stability of that high beta equilibrium. Also, many of the physics phenomena of interest evolve over a period of several seconds.

The DIII-D facility, as presently planned, will be capable of multisecond plasma discharges but will lack a multisecond plasma heating capability. This project will provide for the upgrade of the four existing neutral beam injection systems for 5 second operation and 14 MW of injected power. Two of the neutral beam injection systems were provided by JAERI through the U.S./Japan cooperative program on D-III. This project will allow high quality plasma parameters to be sustained for up to 30 seconds. This is the most cost effective means of obtaining this level of auxiliary heating capability.

*This project will be constructed at GA Technologies, Inc., which is non-Government owned property.

Total Estimated Cost (TEC): $7,400,000

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

Description, Objective and Justification (continued)

The extended pulse heating will allow the plasma temperature in DIII-D to be increased into the low collisionality regime and sustained for several seconds providing sufficient time for detailed investigations to be conducted. As the plasma discharge approaches the collisionless regime, its characteristics are theoretically predicted to change. The transport is altered, therefore, the confinement properties are changed. In addition, the plasma pressure is elevated, producing changes in the MHD activity and the stability of the plasma configuration. The physics of this regime have been studied theoretically, but definitive experiments have not been possible because the proper plasma conditions could not be achieved. Experiments conducted with DIII-D using the modified neutrall beam injection systems are expected to greatly expand our scientific knowledge of this regime.

During 1987, work will be completed on modification of the two neutral beam injection systems for five second operation. Procurement of the new long pulse ion source will be completed and operation of two modified beamlines will begin.

(a) Schedule of Planned Activities

Activity	Start	Complete
Design	1Q FY 1986	3Q FY 1986
Fabrication	2Q FY 1986	2Q FY 1987
Installation	3Q FY 1986	3Q FY 1987
Startup	4Q FY 1986	2Q FY 1988

(b) Management and Contracting

This project will be managed by GA Technologies, Inc., San Diego, California, under separate contract.

(c) Prior Year Achievements

One neutral beam injection system was modified for five second operation. Two long pulse ion sources were procured and installed in the first beam line and tested at full power.

Total Estimated Cost (TEC): $7,400,000

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

(d) Current Year Expectations

Modify a second beamline and procure the remaining seven long-pulse ion sources.

(e) Reasons for Increases and Decreases

The cost estimate for the long-pulse ion source procurement from RCA has increased. The project completion date has been postponed because of budget reductions.

(f) Cost Estimate

Engineering and Design	$ 800
Fabrication and Installation	5,700
Contingency	900
	$ 7,400

Escalation is included at 5% per year.

DEPARTMENT OF ENERGY
1987 CONGRESSIONAL BUDGET REQUEST
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.: 87-R-901

3. Date A-E work initiated: 1st Qtr. FY 1987

3a. Date physical construction starts: 2nd Qtr. FY 1987

4. Date construction ends: 4th Qtr. FY 1988

5. Previous cost estimate: None
Date:

6. Current cost estimate: $8,200
Date: December 1985

7. Financial Schedule:

Fiscal Year	Obligations	Costs FY 1985	FY 1986	FY 1987	After FY 1987
Prior Year Projects	XXXXXXXX	$ 4,245	$ 3,479	$ 2,862	$ 0
FY 1985 Projects	$ 9,400	3,255	4,330	1,815	0
FY 1986 Projects	8,764	0	2,697	4,099	1,968
FY 1987 Projects	8,200	0	0	2,711	5,489
		$ 7,500	$ 10,506	$ 11,487	$ 7,457

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.: 87-R-901

8. Brief Physical Description of Project (continued)

The currently estimated distribution of FY 1987 funds by office is as follows:

1. Los Alamos National Laboratory	$ 300
2. Lawrence Livermore National Laboratory	200
3. Princeton Plasma Physics Laboratory	500
4. Oak Ridge National Laboratory	7,200
	$ 8,200

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 .... $ 300

Requirements include laboratory and office modifications, and additions and upgrading of building service systems as required to meet programmatic goals of the Magnetic Fusion Energy program.

Lawrence Livermore National Laboratory .... $ 200

NMFECC Tape Vault

Princeton Plasma Physics Laboratory .... $ 500*

Safety and fire protection improvements, system modifications and alterations.	100
Repair by replacement CICADA HVAC units	350
Miscellaneous small projects	50

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

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: General plant projects

2. Project No.: 87-R-901

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

Oak Ridge National Laboratory .... $ 7,200

These funds cover the Magnetic Fusion Energy program's responsibility to fund all of the generic General Purpose Plant Projects needs at this multipurpose laboratory.

Air Conditioning Central Mechanical Shops	$ 160
Laboratory Improvements, Biology Administration and Research Building	200
Replace Elevator 2, Biological Research Facility	450
East Parking Lot Lighting Replacement	125
Radiochemical Reprocessing Plant-Evacuation Alarms and Remote Monitoring	95
Fire Protection Installation, Central Research Library	60
Steam Plant Storage Building	52
Computer Science Research Facility	985
Toxic Substance Inhalation Facility	700
Backup Tape Storage Vault	180
New Facilities for Safety, Security, and Efficiency	100
Radiochemical Reprocessing Plant Public Address and Intercom System	255
Separation Science and Technology Facility	650
High Bay Engineering Offices and Laboratories	470
Switchgear Modernization, Biology Research Laboratory Building	830
Facility Upgrade	658
Balance Negative Air Pressure, Fusion Energy Administration, Research Building	280
Containment, Ventilation, Air Routing and Control Systems	950

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.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of Project: General plant projects | 2. Project No.: 87-R-901

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
1987 CONGRESSIONAL BUDGET REQUEST
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.)

PBX Upgrade
Princeton Plasma Physics Laboratory

Total Estimated Cost: $9,200,000
(For Design and Construction)

PBX Upgrade
Princeton Plasma Physics Laboratory*

Total Estimated Cost: $9,200,000

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

	FY 1985 Actual		FY 1986 Estimate		FY 1987 Estimate		Total Project Funding
	B/A	B/O	B/A	B/O	B/A	B/O	B/A
Fabrication							
Operating Expenses	$ 0	$ 0	$ 5,367	$ 5,367	$ 3,833	$ 3,833	$ 9,200
Subtotal	0	0	5,367	5,367	3,833	3,833	9,200
Total Project	$ 0	$ 0	$ 5,367	$ 5,367	$ 3,833	$ 3,833	$ 9,200

Description, Objective and Justification

The presently operating PBX will be modified to allow for increased beta operation in high aspect ratio tokamaks. The upgrade will include reconfiguring the pusher coil to produce higher indentation H-mode operation and adding passive stabilizer plates to control disruptions attributed to external kink modes. The goal is to achieve the highest possible beta operation since beta is a direct measure of the efficiency of magnetic field utilization.

To date all tokamak maximum beta values have been determined by the Troyon limit, which states that beta is proportional to plasma current and inversely proportional to plasma radius and toroidal magnetic field. PBX Upgrade seeks to exceed this theoretical first stability regime limit by indenting the plasma, thereby suppressing the internal kink and ballooning modes. By means of shaping the plasma and passively stabilizing the instabilities, PBX Upgrade should be able to demonstrate whether or not access can be gained to the region of second stability and the correspondingly higher beta values.

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

PBX Upgrade
Princeton Plasma Physics Laboratory

Total Estimated Cost: $9,200,000

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

Description, Objective and Justification (continued)

(a) Schedule of Planned Activities

Activity	Start	Complete
Conceptual Design	1Q FY 1985	1Q FY 1986
Stop PBX Operation	1Q FY 1986	
Fabrication of Parts	2Q FY 1986	1Q FY 1987
Installation of Plates and Coils	3Q FY 1986	1Q FY 1987
Start PBX-Upgrade Operation	2Q FY 1987	

(b) Management and Contracting

This project will be managed by PPPL, Princeton, New Jersey.

(c) Prior Year Achievements

Engineering design was completed. Fabrication and installation of the passive plates, pusher coil, and modification of power supplies and diagnostics commenced.

(d) Current Year Achievements

The upgrade will be completed in the second quarter of FY 1987. Full scale operation will begin in the third quarter of FY 1987.

(e) Reasons for Increases and Decreases

N/A

PBX Upgrade
Princeton Plasma Physics Laboratory

Total Estimated Cost: $9,200,000

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

Description, Objective and Justification (continued)

(f) Cost Estimate (Cost estimate is preliminary)

Engineering and Design	$ 2,000
Fabrication	6,000
Contingency	1,500
Total	$ 9,500