DEPARTMENT OF ENERGY
FY 1991 CONGRESSIONAL BUDGET REQUEST
ENERGY SUPPLY RESEARCH AND DEVELOPMENT

OVERVIEW

BASIC ENERGY SCIENCES

This country has long recognized the importance of basic research and has considered the Federal investment in its scientific base a top national priority. The Basic Energy Sciences (BES) program is an essential component of both the Department and the Federal commitment to R&D in the U.S. today. Working with the national laboratories, universities, industry, and other government agencies, the BES program supports research which provides the foundation for new technologies and improvements to existing technologies which are crucial to achieving the goals described in the National Energy Plan.

Basic research is the first link in the chain of events from scientific discovery to technological innovation. Results from BES sponsored research become an integral part of the information base which underpins the nation's nuclear and non-nuclear technologies. In addition to supporting research for the country's technology foundation, BES supported research helps to train our future scientists, and helps us attain our national goals. Better health and quality of life, economic competitiveness, energy self-sufficiency, and national security are each supported from a strong program in basic research. The research in the BES program is grouped into six major subprogram areas: materials sciences, chemical sciences, applied mathematical sciences, engineering and geosciences, energy biosciences, and advanced energy projects.

The principal focus of the BES program is directed toward supporting the Department's energy goals; however, a number of other important national goals are also supported. The U.S. leadership in science and technology, the stimulation of economic growth, national defense, and the training of tomorrow's scientists are additional goals to which BES contributes through the support of basic research.

BES sponsored research provides the foundation for research in each of the DOE energy technology programs. This link is described in each of the introductions which describe the subprograms within BES. Whether the research is in the Materials Sciences, Chemical Sciences, or any of the other subprograms of BES, the research is primarily driven by the need for enhanced knowledge or understanding which is currently limiting existing energy technologies. The link between basic research and applications, however, is typically not confined to any single energy or technological problem, but has applications to a number of technologies. As an example, a new or improved ceramic material may be applied to energy systems whether they be fossil, nuclear, automotive, or may serve as the most effective way to store radioactive waste. Improved high temperature superconducting materials also hold this same potential to be applied to a number of energy technologies such as more efficient motors, generators, power transmission lines and transportation systems which will have tremendous economic and energy savings. Each of the subprograms in BES support similar

research projects which have applications across a broad range of energy technologies. Whether we are trying to burn coal cleaner, or more cheaply find ways to reduce the overall volume or hazards from wastes, whether nuclear or non-nuclear, each of these problems will ultimately depend on the results from basic research and the applications of those results in the various energy technologies.

The BES program supports research in several ways. The BES program annually supports approximately 1,400 individual research projects at over 200 separate institutions with direct support for over 4,000 investigators in the physical, biological, and mathematical sciences. These projects are selected on the basis of scientific excellence, relevance to support of DOE long-term goals, and their contribution toward a responsive research program. Also, Basic Energy Sciences has a heavy involvement in major scientific user facilities (the High Flux Beam Reactor and the National Synchrotron Light Source at Brookhaven National Laboratory, the Combustion Research Facility at Sandia National Laboratories Livermore, the High Flux Isotope Reactor and the Radiochemical Engineering Development Center (formerly the Transuranium Processing Plant) at Oak Ridge National Laboratory, the Stanford Synchrotron Radiation Laboratory at Stanford University, the Intense Pulsed Neutron Source at Argonne National Laboratory and the Manuel Lujan, Jr. Neutron Scattering Center at Los Alamos National Laboratory).

These major facilities account for a significant amount of the BES budget requirement. In general, facility costs have risen by an amount greater than the cost of living. These higher costs can be attributed to higher than normal utility costs, safeguards, safety and higher user demands, as well as the need for the most modern equipment. The large, expensive, unique facilities in the BES program are made available to qualified users of the U.S. scientific community to the extent that funds permit. At the seven major user facilities funded by BES, there were about 1,500 users from all scientific disciplines and programs which resulted in approximately 790 publications for FY 1989. The activity around these facilities is growing and the number of users is estimated at about 2,000 for FY 1990. Many areas of modern science require large and costly facilities; without them, the necessary advanced research could not be done. BES also is providing advanced state-of-the-art computational support for several Energy Research programs other than Magnetic Fusion Energy [which is directly supported by the National Magnetic Fusion Energy Computer Center (NMFECC)], e.g., High Energy Physics, Nuclear Physics, and Biological and Environmental Research, as well as its own program.

To fully appreciate the importance of the national user facilities, one only has to look at the list of users at the facilities to understand their importance to energy and high technology in this country. For example, at the light sources, the largest U.S. companies (e.g., IBM, AT&T, Exxon, GM) have major research teams doing research in areas such as catalysis, electronics, polymers, biomedical, etc., not only important to those companies, but also important to the DOE goals. At the neutron sources, major oil companies are doing research in porocity of formations and neutron spectroscopy of hydrocarbons in cores and in coal. The Basic Energy Sciences program also has significant research in radiation effects on materials important to fission, fusion, and radioactive waste technology. Major university and Government laboratory teams are

located at the facilities and, just as with the major U.S. companies, the capability made possible at the facilities simply does not exist elsewhere. Advances in materials, chemistry, biology and the next generation of computer chips depend on these facilities.

The BES strategy continues to be:

- o Provide critical knowledge and data by supporting basic research relevant to DOE mission areas;
- o Provide and support operation of unique, specialized research facilities;
- o Exchange information with other DOE programs, Federal agencies, and the academic and industrial scientific communities;
- o Take full advantage of the scientific and industrial communities' identification of needs and opportunities for research in areas likely to be relevant to future energy options;
- o Develop trained scientific talent through support of basic research at universities and national laboratories; and
- o Promote early applications of the results of basic research.

The Basic Energy Sciences program takes advantage of the research capabilities available at national laboratories, government laboratories, universities, and private research laboratories. The program support can be divided into three major components: research, facility operations, and construction. The facility operations component supports the operation of major user facilities for which access by qualified users is provided to the scientific community. Another component of the program, which is the largest component, is research support which takes place at national laboratories, universities and other institutions. By the very nature of the national laboratories and their traditional focus, they are especially valuable in doing research which is applicable to a number of energy concepts. The interactions possible are very great because laboratory scientists are frequently involved in many aspects of the applied energy programs. In addition, the stability of the organization and specialized capabilities which exist at the laboratories in many instances are unmatched. Many of the scientists involved in BES research programs are faculty or students at universities. Their research is enhanced through access to special facilities at national laboratories. More than one-third of BES funding supports university-based research. The list of universities receiving support covers almost every state and includes participation by both large and small institutions. The third component is the construction of facilities needed by the Department and the Nation.

In addition to universities and national laboratories, BES supports research in and maintains ties with industry. Representatives from different industries serve on the BES Advisory Committee; experts from industry participate in the review of research proposals and use the specialized facilities sponsored by

BES; industrial scientists participate in program advisory committees at the national laboratories; and industry representatives are invited to attend BES conferences and workshops on special topics.

The U.S. has been the world leader in science and technology and has derived many economic benefits from its leadership. The Department of Energy and its multiprogram laboratories play an important role in the Nation's scientific enterprise that is essential for our preeminence. A central feature of this role has been construction and operation of large, specialized scientific facilities that are used by scientists from universities and industry as well as the national laboratories. Many of the scientific facilities in our multiprogram laboratories are old. In order to make further progress in certain fields, new, more powerful facilities are required.

In the past few years, the Department has given special attention to correcting deficiencies at its laboratories in environment, health, safety, security, safeguards, multiprogram energy purpose facilities and other such areas. However, less attention has been paid to improving the essential scientific facilities required to accomplish the main scientific mission of the laboratories, i.e., preeminence in certain key fields of research. Three facilities have been identified by the scientific community as being the most critical to the future needs of the Department's Basic Energy Sciences program. The three facilities, all of which will be located at the Department's multiprogram laboratories are: 1-2 GeV Synchrotron Radiation Source - Lawrence Berkeley Laboratory; 6-7 GeV Synchrotron Radiation Source - Argonne National Laboratory; and Advanced Neutron Source - Oak Ridge National Laboratory.

The FY 1991 request for the Basic Energy Sciences program attempts to address not only the need for these powerful new facilities but also a continuing need for research essential to meeting the long-term goals of the Department and Nation. The request can be categorized into three areas: continuation of a strong basic program, operation of major user facilities at reasonable levels, and construction of advanced facilities.

The FY 1991 budget includes the following significant changes to the program underway in FY 1990: 1) a new effort is included in the Advanced Energy Projects subprogram to transfer synchrotron radiation technology (x-ray lithography) to industry for use in developing next generation computer chips; 2) funds are included for the first time for the reimbursement of costs for highly enriched uranium and heavy water used in the operation of the High Flux Isotope Reactor and the High Flux Beam Reactor; and 3) a funding increase has been included as planned to ensure the timely construction of the 6-7 GeV Synchrotron Radiation Source. Other smaller changes in the budget have been made in each of the subprograms in order to address the highest priority goals within the Department. In addition, effective in FY 1990 the management responsibility for the operation of research reactors funded by the Basic Energy Sciences program is now assigned to the Assistant Secretary for Nuclear Energy. Funding responsibility and the scientific utilization of these reactors remains with the BES program.

The FY 1991 budget for the Applied Mathematical Sciences subprogram has been prepared and reviewed to respond to the FCCSET initiative in High Performance Computing. The program that is in place in FY 1989 and FY 1990 is supportive of this initiative within available resources. The DOE program represents an integral component of the government-wide effort. Supplemental material in the Applied Mathematical Sciences justification is provided to explain in greater detail the DOE response to this initiative.

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

LEAD TABLE

Basic Energy Sciences

Activity	FY 1989 Actual	FY 1990 Estimate	FY 1991 Base	FY 1991 Request	Program Change Request vs Base	
					Dollar	Percent
Operating Expenses						
Materials Sciences.....	$173,660	$198,741	$198,741	$221,954	$+ 23,213	+ 12
Chemical Sciences.....	127,817	140,256	140,256	150,500	+ 10,244	+ 7
Applied Mathematical Sciences	42,135	43,705	43,705	47,975	+ 4,270	+ 10
Engineering and Geosciences..	32,770	33,204	33,204	32,500	- 704	- 2
Advanced Energy Projects.....	14,358	14,591	14,591	24,000	+ 9,409	+ 64
Energy Biosciences.....	20,374	20,647	20,647	20,200	- 447	- 2
Program Direction.....	4,900	5,374	6,500	6,500	+ 0	+ 0
Subtotal Operating Expenses...	416,014	456,518	457,644	503,629	+ 45,985	+ 10
Capital Equipment.....	31,700	36,486	36,486	37,019	+ 533	+ 1
Construction.....	86,621	76,833	76,833	108,034	+ 31,201	+ 41
Total.....	$534,335 a/b/	$569,837 b/c/	$570,963	$648,682	$+ 77,719	+ 14
Operating Expenses.....	(416,014)	(456,518)	(457,644)	(503,629)	+ 45,985	+ 10
Capital Equipment.....	(31,700)	(36,486)	(36,486)	(37,019)	+ 533	+ 1
Construction.....	(86,621)	(76,833)	(76,833)	(108,034)	+ 31,201	+ 41
Staffing (FTEs).....	64	70	70	70		

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

a/ Total has been reduced by $5,274,000 which has been transferred to the SBIR program.
b/ Reflects comparability adjustment for new Environmental Restoration and Waste Management program as follows: FY 1989 - $9,677,000; FY 1990 - $12,654,000; FY 1991 - $17,268,000
c/ FY 1990 reflects final Gramm-Rudman-Hollings sequester adjustments.

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(dollars in thousands)

SUMMARY OF CHANGES

Basic Energy Sciences

FY 1990 Appropriation	$ 569,837
Adjustments - Increased personnel costs	+ 1,126
FY 1991 Base	$ 570,963
Operating Expenses	
- Provides funds to meet funding requirements at the major BES user facilities including the reimbursement for the heavy water and highly enriched uranium requirements of the two nuclear reactors (HFIR and HFBR) funded by the BES program	$ 31,715
- Provides a limited increase to address the essential elements of the Govermnent-wide initiative in high performance computing	4,270
- Provides funds to support the transfer of synchrotron radiation technology for use in x-ray lithography important for the next generation of computer chips	10,000
Capital Equipment	
- Provides for a modest increase in equipment costs	533
Construction	
- Provides for continuing projects underway in FY 1990, including funding for General Plant Projects, Accelerator Improvements Projects, and the 1-2 GeV Synchrotron Radiation Source. Additional funds are provided for the 6-7 GeV Synchrotron Radiation Source offset by the funding decrease which resulted by the completion of funding for the 3 GeV Spear Injector	31,201
FY 1991 Congressional Budget Request	$648,682

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(dollars in thousands)

KEY ACTIVITY SUMMARY

BASIC ENERGY SCIENCES

I. Preface: MATERIALS SCIENCES

The Materials Sciences subprogram conducts research aimed at increasing the understanding of materials related phenomena and behavior which addresses the materials needs for safe, reliable, and environmentally acceptable energy technologies including fusion, fission, fossil, solar, geothermal, conservation, and waste containment. The subprogram supports research at DOE laboratories, universities, and to a lesser extent in industry. The laboratory component is the largest and accounts for approximately 50% of the research funding, excluding facility operations. The major laboratory participants are the Ames Laboratory, Argonne National Laboratory, Brookhaven National Laboratory, Oak Ridge National Laboratory, Lawrence Berkeley Laboratory, and to a lesser extent Los Alamos, Lawrence Livermore, Pacific Northwest, and Sandia Laboratories. The laboratory programs as a whole tend to contain larger groups of scientists, are multidisciplinary, and involve longer-term research projects. Many of the DOE laboratory programs have unique, major facilities which are open to outside users from universities, industry, and other government laboratories. The university component of the program includes top researchers from universities throughout the country. A typical project includes several graduate students in addition to the principal investigator. The projects cover all areas of materials sciences and tend to be narrower in scope and of shorter duration than projects at the laboratories. The funding associated with the university portion of the program is approximately 15% excluding facilities funding. Most of the industry supported portion of materials research takes place at smaller businesses through the Small Business Innovation Research program. Other industry groups are funded by their home organization and work with members of the laboratory or university research groups. Due to the unique, expensive, and specialized nature of the user facilities, the largest participation of industry researchers occur at these facilities. So long as the research conducted by industry is available to the scientific community and is of interest to DOE, there is no charge imposed on the industry groups for the use of these facilities.

Groups of multidisciplinary researchers work together guided by opportunities within the general goals set forth by the subprogram. Current goals include uncovering the information needed to: develop new or substitute materials that improve performance or efficiency in energy systems; tailor materials properties to satisfy defined requirements such as improved corrosion resistance in fossil plants or radiation resistance in fusion plants; predict materials problems and service life to improve safety and reliability of components in energy systems; and improve the theoretical and experimental capability to analyze the fundamental structure and behavior of materials. Related to these goals is the support provided for major user facilities which are available to the entire scientific community for research. Coordination among the various materials research efforts within DOE and with other agencies is considered essential. Within DOE this takes place primarily through the Energy Materials Coordinating Committee (EMaCC) and with other agencies through the Committee on Materials (COMAT). Within the Materials Sciences subprogram, research is undertaken in the major areas of metallurgy and ceramics, solid state physics and materials chemistry. Some examples of research accomplishments during the past year include:

I. Preface: MATERIALS SCIENCES (Cont'd)

understanding the mechanism of accelerated embrittlement in nuclear reactor pressure vessel materials, the growth of ceramic films by a biomimetic method, successful development of a computational technique for understanding the atomic structure and mechanical behavior of grain boundaries in metals, direct evidence of lattice stiffening during the transition to superconducting behavior, analysis of the twin boundary structure in a ceramic superconductor, the first superconducting thin films from the new thallium containing high temperature superconductors, nuclear magnetic resonance determination of the valence state of copper in single crystal Y-Ba-Cu oxide superconductors, development of a new nuclear magnetic resonance (NMR) technique called stationary orbit spinning which extends NMR to new classes of materials, and demonstration that neutron reflectometry can be used to characterize the binding and structure of polymeric materials.

II. A. Summary Table

Program Activity	FY 1989 Actual	FY 1990 Estimate	FY 1991 Request	% Change
Materials Sciences Research....	$126,149	$143,380	$141,522	- 1
Facilities Operations.....	47,511	55,361	80,432	+ 45
Total, Materials Sciences....	$173,660	$198,741	$221,954	+ 12

II. B. Major Laboratory and Facility Funding

Argonne National Laboratory....	$ 28,300	$ 31,717	$ 38,832	+ 22
Brookhaven National Laboratory.	38,714	40,602	51,744	+ 27
Lawrence Berkeley Laboratory...	16,236	20,209	26,352	+ 30
Oak Ridge National Laboratory..	30,288	29,008	25,822	- 11

III. Activity Descriptions

MATERIALS SCIENCES

Program Activity	FY 1989	FY 1990	FY 1991
Metallurgy and Ceramics Research	Increased emphasis on processing and understanding structure-property relationships of new high temperature superconductors continued. Effort	Continued emphasis on processing and understanding structure-property relationships of new high-temperature superconductors. Efforts on	Reduction of effort on understanding processing-structure-property relationships in ceramic superconductors. Continue efforts on

III. MATERIALS SCIENCES RESEARCH (Cont'd)

Program Activity	FY 1989	FY 1990	FY 1991
Metallurgy and Ceramics Research (Cont'd)	continued on theoretical approaches to study the behavior of materials, on reliability and lifetime prediction of materials, on bonding and adhesion at interfaces, and on compound semiconductors. Continued approximately constant level of effort on properties of artificially tailored materials, radiation induced changes in materials, fracture in extreme conditions, and advanced energy materials such as high performance metallic alloys, ceramics, and magnetic materials.	theoretical approaches to the behavior of materials, advanced energy related materials such as high-performance alloys and ceramics, bonding and adhesion of interfaces, and of compound semiconductors will continue. Significantly reduced levels of effort on the properties of artifically tailored materials and on fracture.	theoretical approaches to high performance metals and ceramics, structure-behavior relationship to interfacial bonding and adhesion. Continued reduction of effort on artificially tailored materials, fracture behavior and intermetallic compounds. Increase in research on radiation effects of materials, particularly related to waste minimization or reduction.
Solid State Physics Research	Expanded interlaboratory program and new university grants for research on solid state physics of high temperature superconductivity. Use of neutrons and synchrotron radiation for accurate studies of structure, dynamics and electronic configurations of high temperature superconductors. Research emphasizing use of synchrotron radiation, tunneling electron microscopy, ion and molecular beams and other new tools and probes for preparation, characterization and modification of thin films and surfaces. Theoretical research on new materials design. Maintained strength of overall	Sustained thrust via interlaboratory program and university grants for research on solid state physics of high temperature superconductivity. Continue thrust using neutrons and synchrotron radiation for accurate studies of structure, dynamics and electronic configurations of materials. Continued research emphasizing use of synchrotron radiation, tunneling microscopy, ion and molecular beams and other new tools and probes for preparation, characterization and modification of thin films and surfaces. Maintain strength of research effort on a priority basis.	Continue selected efforts and priority research largely unique to DOE, such as in neutron scattering and synchrotron radiation. Reduction of effort on physics of high temperature superconductivity. New effort on field responsive polymeric materials. Continue efforts on solid state physics of surfaces and interfaces. Research on solid state physics of novel materials with energy-related properties and behavior. Increased effort on physics of radiation effects.

III. MATERIALS SCIENCES RESEARCH (Cont'd)

Program Activity	FY 1989	FY 1990	FY 1991
Solid State Physics Research (Cont'd)	research effort but with some shifts in emphasis and support levels to accommodate changing priorities.		
Preconstruction R&D	Continued research and development necessary to support a DOE decision on a new reactor at ORNL.	Continue R&D on ANS.	R&D Support for ANS.
Materials Chemistry Research	Continued in research on new high temperature superconductors with expanded effort in chemical substitution to improve critical parameters. Research started on electrocatalysis using immobilized macromolecules, such as modified enzymes. Continued emphasis on the synthesis of new materials especially using modified or synthetic enzymes to make materials with tailored properties. Research continued on the electronic and magnetic properties of polymeric and organic materials and on high strength polymers. Base program in chemical structure, catalysis, and surface chemistry continues with increased emphasis on structural chemistry at solid-fluid interfaces.	Continue research on new high temperature oxide superconductors as well as organic superconductors emphasizing new synthetic routes to novel, single phase superconductors with improved critical parameters. Continued emphasis on the synthesis of new materials especially using modified or synthetic enzymes to make materials with tailored properties. Research will continue on organic and polymeric materials emphasizing electronic and magnetic properties of synthetic metals, semiconductors, and insulators and also including high strength polymer synthesis. Base program in chemical structure, surface chemical properties and polymer research with emphasis on structural chemistry at solid-fluid interfaces.	Strong emphasis on organic synthesis for synthetic metals, polymer electrolytes, high strength polymer systems, enzymatic systhesis, and the materials chemistry of high temperature superconductors. Synthesis and characterization of other novel materials of long range interest for energy systems, in cooperation with other Division programs. Increased emphasis on study of cooperative interactions of molecular species on surfaces.
	No Activity.	Implementation plans for the Energy Sciences Network (ESNET) project,	Upgrades of ESNET to conform to the National Research and Education

III. MATERIALS SCIENCES RESEARCH (Cont'd)

Program Activity	FY 1989	FY 1990	FY 1991
Materials Chemistry Research (Cont'd)		identified in the Applied Mathematical Sciences subprogram will proceed. This subprogram's share for the implementation of ESNET is $236.	Network standards will continue to be pursued and will be shared among ER programs that benefit from ESNET.
Subtotal Materials Science Research	$126,149	$143,380	$141,522
Facilities Operations	Additional support for major DOE user facilities to meet DOE requirements and user needs at HFBR, NSLS, SSRL, and IPNS. Continued R&D on the advanced scientific facilities: 1-2 GeV and 6-7 GeV lignt sources and the Advanced Neutron Source.	Continue support of national user facilities. Budgeted for preconstruction R&D for the 1-2 GeV and the 6-7 GeV light sources.	Increased support for major facilities in the Materials Sciences subprogram. Increased funding for uranium conversion and enrichment, heavy water costs, and safety requirements at HFBR. Increased support for R&D and commissioning of components at 1-2 GeV and 6-7 GeV light sources.
Subtotal Facilities Operations	$47,511	$55,361	$80,432
Total, Materials Sciences Operating Expenses	$173,660	$198,741	$221,954
Percentage Breakdown by Performer			
Laboratory	51%	50%	48%
University	20%	20%	14%
Industrial/Other	2%	2%	2%
Facility Operations	27%	28%	36%
Subtotal	100%	100%	100%
Number of Researchers Supported	1,045	1,045	1,090

I. Preface: CHEMICAL SCIENCES

The Chemical Sciences subprogram supports basic research across a broad front of chemistry and atomic physics necessary for the mid and long term development of energy technologies. Research includes photochemistry important to the conversion of light energy to fuels or electricity, chemical physics related to combustion processes and more efficient utilization of fossil resources, atomic physics important to fusion concepts, heavy element chemistry important to waste management, organic chemistry as well as heterogeneous and homogeneous catalysis related to coal conversion and better processes for the production of fuels and bulk chemicals, separations and analytical science related to almost every facet of process chemistry and nuclear energy technology, and chemical thermodynamics for predicting physical properties of complex hydrocarbon mixtures such as fuels. Basic research in these areas of chemistry related to the development of environmentally safe energy technologies and innovative approaches to waste management and cleanup are also supported. Recent noteworthy examples of research results that have had technological impact can be cited. One is the discovery and development of highly selective extractants leading to the TRUEX process for removing actinide elements from acidic solutions of high level radioactive waste. Another is the fundamental kinetics research that led to the RAPRENOX process for removing oxides of nitrogen, NOx, from combustion exhaust gases. Consistent with these goals, support is provided to major user facilities which are available to the entire scientific community for research. The budget for the Chemical Sciences subprogram is affected in a significant way in FY 1990 and FY 1991 by the necessity to meet facility requirements above the needs of the base research program. A number of studies, including a National Academy of Sciences study, recommended a number of safety improvements at the High Flux Isotope Reactor which are being addressed in both the FY 1990 and FY 1991 budgets. Other facility operating budgets are increasing substantially in FY 1991 to deal with maintenance problems and provide for more optimal use.

II. A. Summary Table

Program Activity	FY 1989 Actual	FY 1990 Estimate	FY 1991 Request	% Change
Chemical Sciences Research.....	$ 84,105	$ 97,137	$ 95,987	- 1
Facilities Operations.....	43,712	43,119	54,513	+ 26
Total, Chemical Sciences.....	$127,817	$140,256	$150,500	+ 7

II. B. Major Laboratory and Facility Funding

Argonne National Laboratory....	$ 16,538	$ 15,423	$ 15,523	+ 1
Brookhaven National Laboratory.	15,838	16,059	17,203	+ 7
Oak Ridge National Laboratory..	38,473	34,400	40,554	+ 18

III. Activity Descriptions

CHEMICAL SCIENCES

Program Activity	FY 1989	FY 1990	FY 1991
Chemical Sciences Research	Theoretical and experimental examinations of the role of solvents in photochemical charge separation phenomena of model compounds designed for efficient conversion have been carried out.	The highest priority programs in chemical dynamics of combustion reaction systems and chemical catalysis would receive cost of living increases somewhat at the expense of existing programs. Research programs at the CRF and NSLS would continue at current levels. Most other programs would remain at FY 1989 or slightly reduced dollar levels. Modest growth is planned on photocatalysis, photoselective reaction pathways, solvent effects on photo induced electron transfer, and surface chemistry at semiconductor electrodes. Research on recoil hot atom chemistry will be reduced.	The characterization of solvent effects on photoinduced electron transfer which is critically important for solar photochemical energy conversion technologies will receive preferred emphasis, as will the related areas of photosynthesis and photoelectrochemistry. Studies on the characterization of solution properties using radiation chemistry techniques and the unique chemistry of highly energetic atoms will be maintained.
	Emphasis continued on the dynamics of small combustion related species central to improved models of combustion processes, and on metal cluster chemistry that may underpin an understanding of bulk properties.	New and/or increased efforts in research on the mechanisms of soot formation and the dynamics of chemical reaction related to combustion will be initiated. Cost-of-living adjustments will be deferred for those activities less directly related to combustion and cluster science related to catalysis. Support will be provided for expanded experimental and theoretical basic research in molecular sciences related to environmentally safe uses of energy and waste management.	Theoretical and experimental research on the detailed dynamics of chemical reactions related to combustion remains a high priority effort and will continue unabated. Support will increase for fundamental studies of interactions of atoms and molecules with surfaces and clusters as a means for developing general theories of catalysis. High priority will be given to experimental and theoretical research in molecular aspects of interfacial science to understand the reactivity and control or prevent transport of hazardous chemicals and species in the environment. The

Program Activity	FY 1989	FY 1990	FY 1991
Chemical Sciences Research (Cont'd)			availability of powerful supercomputers and laser-based optical techniques capable of time resolution of less than a trillionth of a second now allow the study of increasingly complex chemical reactions at a level of detail required to characterize processes spanning a diversity of existing and emerging energy technologies including artificial photosynthesis, combustion, and catalysis. The expanded effort will emphasize both theoretical and experimental efforts to characterize extremely fast or short-lived phenomena. The CRF will contribute substantially to the combustion part of this expanded effort.
	Dynamical effects of atomic systems in intense energy fields that occur under high flux conditions of photons, electrons or ions were studied. The Kansas State University Ion Collision Physics Facility has become completely operational.	New efforts in low temperature plasma physics research will be started to the degree possible. Studies designed to unravel ionic structures and the dynamics of interactions involving photons, electrons, and ions in atomic systems exposed to strong electrical and magnetic fields will be maintained.	Research on the characterization of the electronic structure and dynamics of multiply charged ions, particularly the exchange of energy and momentum during collisions of these ions with other ions, atoms, electrons, and photons, remains a high priority, benefitting both fusion energy and X-ray laser development. The program in theoretical atomic physics will be expanded. Recent experimental progress in the area of high-energy, atomic physics under extreme

Program Activity	FY 1989	FY 1990	FY 1991
Chemical Sciences Research (Cont'd)			conditions far outstrips the theoretical and computational tools needed for the application of newly acquired knowledge to the development of fusion energy and X-ray laser technologies. New and improved theories are required to guide new experiments and to interpret existing data. Special attention will be given to university-based efforts in order to address a serious national shortage of high quality scientists trained in modern atomic physics theory.
	Research on shape selective oxide catalysts for the energy efficient conversion of paraffinic hydrocarbons to bulk chemicals were given priority. An initiative on research related to high temperature superconductors was started. The synthetic chemistry of novel inorganic and organometallic compounds and polymers which can serve as precursors to the new classes of perovskite ceramic superconductors has been examined.	The new program in materials precursor chemistry will be expanded to include chemistry of other advanced materials in addition to high temperature superconductors at the expense of selected projects in solution chemistry and isotope effects research. Heterogeneous and homogeneous catalysis research and the studies of the chemical and physical properties, structures, and reactivity of coal macromolecules will be continued.	Research programs in materials precusor chemistry, catalysis and coal chemistry will be given priority. Research leading to novel organometallic polymers, layered and zeolitic structures, membranes, polyoxmetallates, and metal clusters will be supported. Their use in the preparation of advanced semiconductors, polymers, catalysts, superconductors, coated electrodes and separation membranes will be explored.

Program Activity	FY 1989	FY 1990	FY 1991
Chemical Sciences Research (Cont'd)	Combustion related turbulence research and thermophysical properties of fossil derived mixtures continued to be emphasized.	Emphasis will be given to predictive models for fluid properties and phase equilibria of polymers, polydisperse systems and reverse micelles in supercritical fluids at the expense of lower priority research.	Continued emphasis will be given to thermodynamic properties of complex fluid mixtures involving large molecular size differences or energies of interactions as well as chain type molecules and ions.
	Research to effect direct measurement of heteroatoms in solid matrices such as coal were carried out. Novel analytical methods for handling polar compounds and direct chromatographic analysis of fossil derived process streams were explored.	The study of membrane separations methods of aqueous and gaseous species will be emphasized. The analytical characterization and speciation of trace components in aqueous media will be pursued.	The chemistry of interfacial phenomena important to membrane and other separations processes will be increased. Analytical methods to determine the spatial distribution and identity of molecular species at interfaces such as a membrane liquid interface will be supported. The design and synthesis of specific molecules complexing agents and reverse micelle work at near critical conditions will be modestly enhanced.
	Further research on actinide electronic properties and bonding in high temperature solid state mixed oxides and organoactinides were performed. Solid state actinide chemistry related to the lanthanide containing high temperature superconducting ceramic materials were investigated.	Theoretical calculations of the electronic properties of the heaviest actinide and transactinide elements to assess relativistic effects will be emphasized. High temperature thermodynamic studies of solid compounds to determine chemical stabilities and the effects of high pressure on actinide metal and compound properties will be pursued.	Research on highly sensitive methods for speciation of solution actinide species will be increased. The chemistry of actinides in superconducting mixed oxides will be extended. New experimental and theoretical investigations on the stabilities of high temperature molecular species will be pursued.

III. CHEMICAL SCIENCES (Cont'd)

Program Activity	FY 1989	FY 1990	FY 1991
Chemical Sciences Research (Cont'd)	No activity.	Implementation plans for the Energy Sciences Network (ESNET) project, identified in the Applied Mathematical Sciences subprogram will proceed. This subprogram's share for the implementation of ESNET is $172.	Upgrades of ESNET to conform to the National Research and Education Network standards will continue to be pursued and will be shared among ER programs that benefit from ESNET.
Subtotal Chemical Sciences Research	$84,105	$97,137	$ 95,987
Facilities Operations	Continued support for major user facilities to meet the needs of the national user community as well as the DOE. Operational support maintained at the FY 1988 levels for facilities including the High Flux Isotope Reactor which has been shutdown to correct safety problems.	Support for major user facilities at the FY 1989 level will be maintained. Continues with restart improvements at the HFIR. Redirection of additional funds will be required to meet all restart and safety requirements.	More optimal levels of support for major user facilities will be established in FY 1990. The safety, quality assurance and physical facility improvements planned for the HFIR will be carried out. Increases for the CRF for ultra fast dynamics and theoretical computing capability will be provided. Included for the first time in this budget are funds for the highly enriched uranium needed for the HFIR fuel.
Subtotal Facilities Operations	$43,712	$43,119	$54,513
Total Chemical Sciences Operating Expenses	$127,817	$140,256	$150,500

III. CHEMICAL SCIENCES (Cont'd)

Percentage Breakdown by Performer			
Laboratory	35%	32%	33%
University	30%	30%	30%
Industrial/Other	3%	3%	3%
Facility Operations	32%	35%	34%
Subtotal	100%	100%	100%
Number of Researchers Supported	877	877	900

I. Preface: APPLIED MATHEMATICAL SCIENCES

Applied Mathematical Sciences has two activities: Mathematical Sciences Research and Energy Sciences Advanced Computation. The objectives of the Mathematical Sciences Research activity are: (1) to expand the knowledge of the fundamental mathematics and computer science principles necessary to model the complex physical phenomena involved in energy production systems and basic sciences, and (2) to explore new future computational algorithms and computer architectures necessary for investigating these mathematical models. Near term objectives include a rigorous mathematical investigation of current modeling activities in global warming, groundwater transport of pollutants, superconductivity, and complex systems. Mid-term and long-range activities include investigation of the mathematical and computer science techniques to improve the utilization of these modeling activities on the parallel computer architectures of the future. This activity includes the acquisition of new and innovative computational research computer hardware and/or software which is on the leading edge of technology. These items are subject to short acquisition lead times and therefore, it is often not possible to specifically identify each item in the budget. The primary purpose of these items is to allow the evaluation of new computer hardware and/or software approaches by the Department to determine their potential use in supporting the advanced computational operational requirements of this program.

The objective of the Energy Sciences Advanced Computation activity is to provide access to the highest quality state-of-the-art supercomputers and the software relevant to researchers supported by the Office of Energy Research.

APPLIED MATHEMATICAL SCIENCES (Cont'd)

II. A. Summary Table

Program Activity	FY 1989 Actual	FY 1990 Estimate	FY 1991 Request	% Change
Mathematical Sciences Research	$ 24,439	$ 24,882	$ 27,800	+ 12
Energy Sciences				
Advanced Computation	17,696	18,823	20,175	+ 7
Total Applied Mathematical Sciences	42,135	43,705	47,975	+ 10

II. B. Major Laboratory and Facility Funding

Ames Laboratory.....	$ 885	$ 980	$ 1,050	+ 7
Argonne National Laboratory....	4,710	4,440	4,600	+ 4
Lawrence Berkeley Laboratory...	1,730	1,830	2,055	+ 12
Lawrence Livermore Nat. Lab....	1,500	1,475	1,750	+ 19
Los Alamos National Laboratory.	1,650	2,010	2,100	+ 4
Oak Ridge National Laboratory...	1,915	2,015	2,200	+ 9
Sandia Laboratories.....	1,235	1,555	2,025	+ 30
Supercomputer Centers.....	17,155	18,203	18,000	- 1

III. Activity Descriptions

APPLIED MATHEMATICAL SCIENCES

Program Activity	FY 1989	FY 1990	FY 1991
Mathematical Sciences Research	New projects in mathematics (algebraic geometry and group theory) addressing concepts in superstring theory (with joint funding from theoretical high energy physics) continue at same level as last year, as do the projects in the field of nonlinear hyperbolic conservation laws and numerical linear algebra.	The level of effort in analytical and numerical mathematics will be maintained.	Research in analytical and numerical mathematics will continue at the same level. New projects in complex nonlinear dynamical systems will be initiated. A postdoctoral fellowship in computational mathematics will be started to provide two fellowships for each major laboratory with substantial participation in the

III. APPLIED MATHEMATICAL SCIENCES (Cont'd)

Program Activity	FY 1989	FY 1990	FY 1991
Mathematical Sciences Research (Cont'd)			Mathematical Sciences research activity.
	Projects in data analysis, display and management techniques continue, with emphasis on new visualization techniques available on the high speed scientific workstations now available.	Projects in data analysis, display and management will be curtailed somewhat as ongoing projects finish their current funding cycle in order to provide a constant level of effort in the other categories.	Projects in data analysis, display and management will receive increased attention, in order to investigate new techniques for handling large scale scientific data on new parallel architecture computing systems.
	Research on high level languages for parallel computer systems continues at same level of effort. The large university projects at NYU, University of Illinois, and Cal Tech are being reviewed this year to assess the progress in investigating three classes of parallel architectures suitably scalable to be potential for future supercomputers.	Research projects in advanced computing concepts will be curtailed somewhat, particularly in terms of providing new computing resources and support staff in order to maintain a constant level of research effort.	Research projects that support investigation of scientific problems on parallel architecture computing systems will begin building up to critical mass in the major laboratories supported by the AMS program. Progress on adapting new algorithms to new architectures will focus on those techniques suitable to the "grand challenge" problems in physics, chemistry, biology, ecology, materials, and environmental studies.
Subtotal Mathematical Sciences Research	$24,439	$24,882	$27,800

III. APPLIED MATHEMATICAL SCIENCES (Cont'd)

Program Activity	FY 1989	FY 1990	FY 1991
Energy Sciences Advanced Computation	Continues support for operations of the National Magnetic Fusion Energy Computer Center at LLNL with the enhanced Class VI acquired last year. Funding continued for FSU/SCRI as directed by Congress.	Continues funding for supercomputer access to NMFECC. Proceeds with the acquisition of a Class VII supercomputer to replace some of the older Class VI systems in use last year at both NMFECC and FSU. Delivery of the new Class VII is anticipated late in FY 1990. Funding continued for FSU/SCRI as directed by Congress.	Continue full operation of and access to Class VII supercomputer systems by the ER research community. A Cray 2 will be released as soon as the Class VII acquisition is completed.
	Continue migration to Energy Sciences Network to replace the MFENet, which is obsolete. Total funds devoted to ESNET were $1.1 million.	Implementation plans for the Energy Sciences Network project will proceed. Total funds requested are $4.0 million, $0.5 million in the Applied Mathematical Sciences subprogram and the remainder shared among all ER research programs.	Upgrades of ESNET to conform to the National Research and Education Network standards will continue to be pursued. Total funds requested are $4.2 million, shared among all ER research programs.
Subtotal Energy Sciences Advanced Computation	$17,696	$18,823	$20,175
Total Applied Mathematical Sciences	$42,135	$43,705	$47,975

APPLIED MATHEMATICAL SCIENCES (Cont'd)

Percentage Breakdown by Performer

Laboratory	52%	48%	73%
University	44%	48%	21%
Other	4%	4%	6%
Subtotal	100%	100%	100%
Number of Researchers Supported	261	295	300

DOE Response to the FCCSET High Performance Computing Initiative

The report "A Research and Development Strategy for High Performance Computing" issued by the Office of Science and Technology Policy in November 1987, documents a strategy for enhancing the research base in computing and computer science and engineering supported by the Federal government in order to maintain U.S. economic competitiveness and ensure technological strength of our national defense. The implementation plan describes the role of the major funding agencies in the Federal government and proposes a plan to strengthen specific research activities and to maintain the close coordination of these activities to ensure that the U.S. industry, academia, and national laboratories are in the forefront to the design and application of modern computing systems.

Four areas of interest are described in the implementation plan:

(1) High performance computing systems, including research for future generations of computing, system design tools, advanced prototype development, and early systems for evaluation;
(2) Advanced software technology and algorithms, including support for software to address "grand challenge" problems, software components and tools, computational techniques, and advanced computing research centers;
(3) The National Research Network, including an interagency effort to produce an interim research network, research and development for a gigabit network, deployment of this new gigabit network, and structured transition to commercial service;
(4) Basic research and human resources, including enhanced support for modern mathematics and computer science departments, science and engineering educational programs to ensure an adequate supply of research talent, and strengthening of the basic research efforts in computational sciences.

DOE Activities:

The support for research and development in high performance computing is continued in the Applied Mathematical Sciences (AMS) subprogram in the Basic Energy Sciences program budget. The AMS subprogram has responsibility for most of the activities in the four categories described above for all programs in the Office of Energy Research and, with respect to basic research, for all of DOE.

I. Preface: ENGINEERING AND GEOSCIENCES

In summary the Applied Mathematical Sciences subprogram is responsive to the FCCSET High Performance Computing Initiative. DOE will continue to work closely with OSTP and the other agencies in carrying out these activities.

The Engineering and Geosciences subprogram supports DOE's central fundamental research activities in the engineering and geosciences disciplines. The engineering research objectives are (1) to improve and advance our knowledge of processes underlying current engineering practice, and (2) to expand the store of fundamental concepts for solving anticipated and unforeseen engineering problems in energy technologies. Fundamental research is supported in both traditional engineering disciplines and interdisciplinary areas. The research is concerned especially with analysis, control and improvement of systems for transport of heat and fluids and for materials processing. Because of their basic nature, the results of specific engineering research projects are expected to affect more than one energy technology. Thus, for example, successful efforts in basic multiphase flow studies will impact nuclear reactor technology, waste management, rehabilitation of the environment, tertiary oil recovery methods and renewable energy technologies. Similar wide impact is expected of heat transfer research. At the same time, advances in instrumentation and systems control are leading to innovative and improved approaches in chemical and materials processing and manufacture which will save energy and extend equipment lifetimes.

The geosciences research objective is to develop a quantitative, predictive understanding of the energy-related aspects of the earth sciences. The scope of work reflects the fact that all energy resources come from the earth and the sun and all waste products are returned to the earth and its atmosphere. The primary focus of the Geosciences program is on the geophysics and geochemistry of rock/fluid system, including emphasis on high resolution underground imaging. Other topics emphasized in the program include geochemical migration, basic geosciences studies of sedimentary formations where oil and gas are located, continental scientific drilling and isotopic studies. This research is expected to pay off in improved approaches to the recovery of oil and natural gas, solutions to problems in the isolation of hazardous wastes and environmental restorations, and advances in our knowledge of, and access to, the full range of the earth's energy resources. The earth sciences also play a key role relative to treaty verification and underground testing of nuclear weapons. The high relevance of the Geosciences program to a secure energy supply for the nation and the special expertise of the DOE laboratories in integrating basic research with technology programs are key elements in the growing recognition of the importance of geosciences research in DOE.

II. A. Summary Table

Program Activity	FY 1989 Actual	FY 1990 Estimate	FY 1991 Request	% Change
Engineering Research.....	$ 15,152	$ 15,354	$ 15,022	- 2
Geosciences Research.....	17,618	17,850	17,478	- 2
Total, Engineering and Geosciences.....	$ 32,770	$ 33,204	$ 32,500	- 2

II. B. Major Laboratory and Facility Funding

Lawrence Berkeley Laboratory...	$ 2,587	$ 2,655	$ 2,604	- 2
Los Alamos National Laboratory.	2,775	2,656	2,608	- 2
Sandia, Albuquerque.....	2,332	1,932	1,914	- 1

III. Activity Descriptions

ENGINEERING AND GEOSCIENCES

Program Activity	FY 1989	FY 1990	FY 1991
Engineering Research	The appropriation provided for maintaining the same overall level of effort as in FY 1988. Basic research in energy related engineering offers ways for major improvements in energy systems design. New diagnostic and modeling methods for two-phase flows, for example, are replacing empirical correlations with vastly better models based on fundamental understanding of the underlying phenomena. This contributed to the resolution of a prime concern with reactor safety codes, namely the behavior of steam and water at high temperature and high pressure. Similar studies were extended to porous media which played a role in the recovery of oil and natural gas deposits, as well as in other energy systems. Research in solid mechanics lead to major progress in the ability to predict life-to-crack-initiation of structural components. Research efforts continued to address the fundamental areas of process design and control, non-destructive evaluation, instrumentation for hostile environments, and intelligent machines. With respect to the last, experiments at ORNL demonstrated	Support for basic engineering research will be maintained at a level of effort slightly below that of FY 1989. Emphasis will remain on the most critical aspects of two-phase flows and flows in porous media; in the latter case the collaboration between MIT, Sandia National Laboratory and Los Alamos National Laboratory will continue experiments aiming at the validation of advanced methods for analyzing such flows. At the same time it is expected that ongoing theoretical and experimental collaborative work at three universities will cast light on the evolution of persistent organized large scale structures in turbulent flows. Some support for attacking basic engineering problems in high temperature superconducting devices will be provided. Research will continue in the areas of combustion, welding automation and plasma processing, as will studies in solid mechanics, and the dynamics of non-linear systems and smart controls for energy systems. Investigations of novel approaches to engineering problems based on recent advances in the theory of dynamical systems, such	The request will provide continued support for long term basic engineering research in the areas of Mechanical Sciences, Control Sciences, Engineering Data and Analysis somewhat below the FY 1989 level of effort. There will be a 10% reduction in the number of graduate students supported by this subactivity. Research in multiphase flow will continue with emphasis on two-phase flow of liquids and gases and flow in porous media. These studies are not only important in many energy conversion devices but are also of importance to recovery of oil and gas deposits, management of nuclear waste repositories, and the Department's long-term environmental restoration program. Research in non-linear dynamical systems will be continued with slightly diminished support for experts in theory of chaos and non-linear dynamical systems drawn from such fields as engineering, mathematics, physics, chemistry, biology, and economics. Such theory is needed to model and study the evolution of engineering, physical,

Program Activity	FY 1989	FY 1990	FY 1991
Engineering Research (Cont'd)	modes of operation in which two independent machines acting jointly under limited human supervision carry out a set of requested tasks. Studies carried out in the University-INEL collaborative project included developing efficient control strategies for automated welding processes, and the development of optical techniques for plasma diagnostics and process control. Further studies continued to address the fundamental engineering aspects of combustion and methods for acquisition of thermophysical data for energy related processes. Systems using the new superconductors were studied by, for example, use of non-destructive evaluation techniques to see changes associated with transformations to the superconducting state.	as new efficient energy conversion cycles made possible by resonances between coupled oscillatory chemical reactions and mechanical process, will continue. This subactivity will continue to stimulate wide collaboration between national labs and universities in appropriate areas of interest.	biological, and economic systems. Existing, strong collaborative work among universities, industries and national laboratories will be continued in such diverse areas as welding automation, plasma processing, combustion, intelligent machines, structural life prediction, etc. Due to the overall decrease in the level of effort, the flow of research results for practical industrial applications will be somewhat diminished.
	No activity.	Implementation plans for the Energy Sciences Network (ESNET) project, identified in the Applied Mathematical Sciences subprogram will proceed. This activity's share for the implementation of ESNET is $20.	Upgrades of ESNET to conform to the National Research and Education Network standards will continue to be pursued and will be shared among ER programs that benefit from ESNET.
Subtotal Engineering Research	$15,152	$15,354	$15,022
Geosciences Research	A major effort was initiated to improve remote high-resolution, three-dimensional mapping	Continued funding will be provided for high resolution underground imaging of geologic media using	Continued emphasis will be given to the geological approaches which best illuminate the spatial relations of

III. ENGINEERING AND GEOSCIENCES (Cont'd)

Program Activity	FY 1989	FY 1990	FY 1991
Geosciences Research (Cont'd)	capabilities using elastic waves (i.e., acoustic and shear waves) for underground imaging. Techniques for high data-rate processing and large array synthesis were developed and applied to advance the state-of-the-art. This research seeked to provide the increased resolution necessary to define geologic discontinuities with an accuracy suitable for application to the requirements of waste isolation and hydrocarbon reservoir studies. In addition, other lines of research were in progress related to sedimentary basins which contain oil and gas resources. Rates of conversion of kerogen to petroleum, rock mechanics, fluid-rock interactions, geochemical transport, and isotopic tracer studies are major components of this effort. Thermodynamic properties of melts, brines, and other fluids comprised an important part of geochemical research this year. Results of these studies were applied to a better understanding of thermal regimes and the evolution of sedimentary basins. In the area of continental scientific drilling, a drill hole in the Valles Caldera, New Mexico, was completed early in FY 1989 to 1.7 km, about 200m into the conductive zone of an active hydrothermal system.	elastic waves. New techniques for high data-rate processing, large array synthesis and the interpretation of seismic data in terms of geologic media parameters such as permeability will be part of this effort. Because of its application to DOE interests in radioactive and hazardous waste disposal, hydrocarbon reservoir studies, and geologic media in general, underground imaging is expected to play a key role in the Geosciences Research activity, and funding for this effort will be maintained in FY 1990. An appropriate balance of research in other areas of the geosciences will be continued. Research related to sedimentary formations in which oil and gas resources are located will be emphasized. Research in regions of high heat flows (thermal regimes) will aid in better understanding of the heat sources responsible for the maturation of hydrocarbon-bearing sediments and for geothermal energy resources. Other research topics receiving emphasis will include geochemical migration, permeability studies, isotopic tracer studies, fluid flow, and solar-terrestrial-atmospheric interactions. Continental scientific drilling	crustal rocks and fluid flow in the crust, to research on high-resolution geophysical imaging, permeability studies, rock/fluid interactions, isotopic tracer studies, and scientific drilling. Because predictions of fluid flow in situ are so often unsatisfactory, numerical modeling studies will be needed to explore the connections and sources of error in fluid flow results obtained from laboratory and field scale experiments. New theoretical approaches for predicting fluid flow in heterogeneous media will be explored. Basic studies will be maintained dealing with oil, gas, and water reservoirs, including causes and distributions of permeability of reservoir rocks, rock fracture properties, and rock stress states. Studies of solar-terrestrial atmospheric interactions and appropriate solid earth studies will be pursued. The environmental impact statement for the Katmai (Alaska) scientific drilling project will be completed in preparation for drilling, which is targeted for 1992. Additional field investigations will also be completed at Katmai in 1991.

III. ENGINEERING AND GEOSCIENCES (Cont'd)

Program Activity	FY 1989	FY 1990	FY 1991
Geosciences Research (Cont'd)	Geophysical surveys of the proposed drill site at Katmai in Alaska were carried out. Solar-terrestrial physics research concentrated on the relationship between the near-space environment of the earth and the upper and middle atmosphere.	research will be maintained, particularly at Katmai in Alaska.	
	No activity.	Implementation plans for the Energy Sciences Network (ESNET) project, identified in the Applied Mathematical Sciences subprogram will proceed. This activity's share for the implementation of ESNET is $20.	Upgrades of ESNET to conform to the National Research and Education Network standards will continue to be pursued and will be shared among ER programs that benefit from ESNET.
Subtotal Geosciences Research	$17,618	$17,850	$17,478
Total Engineering and Geosciences Operating Expenses	$32,770	$33,204	$32,500
Percentage Breakdown by Performer			
Laboratory	49%	49%	48%
University	45%	45%	45%
Industrial/Other	6%	6%	7%
Subtotal	100%	100%	100%
Number of Researchers Supported	401	392	375

I. Preface: ADVANCED ENERGY PROJECTS

The objective of the Advanced Energy Projects (AEP) subprogram is to explore the feasibility of novel, energy-related concepts, as they evolve from basic research. Such concepts are at an early stage of scientific definition and, therefore, would not qualify for support by technology programs. Because they are new and untried, those concepts invariably represent high risk. To qualify for AEP support, the concepts must also have a potential payoff of a magnitude sufficient to open new vistas for the Nation's energy posture. Projects such as the exploration of new approaches to controlled fusion and of unconventional applications for superconducting materials can lead to dramatic energy-related implementations. Major consideration is given to facilitate a transfer of successful AEP projects to the proper technology program, whether in the Government or in the private sector. Transfers are effected every year, with several leading to major development programs.

The principal mode of operation for this interdisciplinary subprogram is to support individual projects for a limited time only. It differs from other subprograms in that ongoing evolutionary research is not funded. The spectrum of projects supported is very broad and encompasses the range of the Department's non-defense interests. Close contact is maintained with other DOE technology programs to ensure proper coordination. Projects are selected on the basis of unsolicited proposals received from researchers at universities, industrial laboratories (especially small R&D companies) and national laboratories.

A separate activity within AEP is the Heavy Ion Fusion Accelerator Research (HIFAR) program. HIFAR conducts research and development on the heavy-ion, induction linear accelerator method to assess its suitability as a "driver" for electric power plants based on the principle of inertial confinement fusion. In this approach to fusion, output from the driver is used to compress small pellets of fuel to the extent that energy-producing thermonuclear reactions occur. (The other inertial fusion driver contenders, lasers and light-ion accelerators, are being developed elsewhere within DOE.)

II. A. Summary Table

Program Activity	FY 1989 Actual	FY 1990 Estimate	FY 1991 Request	% Change
Advanced Energy Projects.....	$ 14,358	$ 14,591	$ 24,000	+ 64
Total, Advanced Energy Projects.....	$ 14,358	$ 14,591	$ 24,000	+ 64

II. B. Major Laboratory and Facility Funding

Lawrence Berkeley Laboratory...	$ 5,014	$ 4,860	$ 4,800	- 1
Los Alamos National Laboratory.	2,061	1,193	1,200	0

III. Activity Descriptions

ADVANCED ENERGY PROJECTS

Program Activity	FY 1989	FY 1990	FY 1991
Advanced Energy Projects	As is the case every year, new highly nonconventional energy-related concepts, as they emerge, were explored for their technical feasibility. Continued emphasis was on concepts for very bright laser-type x-ray sources and their applications, especially in the area of x-ray laser holography and microscopy, for imaging of living matter at subcellular levels; the work was coordinated with the Biological and Environmental Research program. Muon-catalyzed fusion was further explored for its potential as an alternative to other fusion schemes. The Heavy Ion Fusion Accelerator Research program was continued to complete and document existing major research activities within the program; emphasis was placed on maximizing the scientific return on the sizable investment in the existing HIFAR experimental apparatus.	Funds will be used to support exploratory research on innovative energy-related concepts which evolve from basic research but are in need of proving their practical feasibility. As has been the case for over a decade, all projects are supported for a limited period of time, in most cases not exceeding three years. Subjects studied by researchers at universities, national laboratories, and industrial laboratories span the full spectrum of Departmental non-defense interests and presently include areas such as unconventional approaches to superconductor development, entirely new approaches to chemical separations, new sources of coherent electromagnetic radiation, including x-ray lasers, applications of such sources to microscopic imaging of live matter at subcellular levels, and muon-catalyzed fusion or "cold-fusion"-- an approach to fusion energy generation that does not require high temperatures. The Heavy Ion Fusion Accelerator Research (HIFAR) effort will continue towards an understanding of key beam physics and accelerator technology issues	Provides funds to continue with the mission to establish the technical feasibility of novel and highly unconventional concepts that span the Department's interests in energy technologies, as they emerge from basic studies. Projects currently underway at universities, national laboratories and industrial laboratories will be continued towards completion. These projects are in areas that include novel sources of short-wavelength radiation, unconventional approaches to chemical separations, innovative fossil fuel technology, and alternative approaches to fusion. As existing projects are completed, promising new concepts can be considered for support. Program vitality will be maintained by initiating approximately 10 new projects during the fiscal year. The Heavy Ion Fusion Accelerator Research (HIFAR) effort will continue towards its objective with existing apparatus. Emphasis will be placed on using the ion injector system to examine the physics issues associated with the transition from low to medium beam energies in a driver.

III. ADVANCED ENERGY PROJECTS (Cont'd)

Program Activity	FY 1989	FY 1990	FY 1991
Advanced Energy Projects (Cont'd)		through the comprehensive utilization of existing apparatus. The injector system will be used to probe the parameter space of physics associated with transporting very high-current beams of heavy ions.	Provides funds to rapidly transfer synchrotron x-ray source technology from DOE laboratories to the semiconductor industry. This technology is the cornerstone of a promising technique, called x-ray lithography, for mass producing the next generation of computer chips. Although DOE laboratories are among the world leaders in developing research-quality synchrotron rings, US industry lacks the expertise to expeditiously adapt this technology for manufacturing semiconductor devices on a commercial scale. This initiative will be closely coordinated with the Department of Defense as each Department has a strong programmatic interest in the mass production of advanced computer chips. This activity is proposed to be 50/50 cost shared with industry.
	No activity.	Implementation plans for the Energy Sciences Network (ESNET) project, identified in the Applied Mathematical Sciences subprogram will proceed. This subprogram's share for the implementation of ESNET is $20.	Upgrades of ESNET to conform to the National Research and Education Network standards will continue to be pursued and will be shared among ER programs that benefit from ESNET.
Total Advanced Energy Projects Operating Expenses	$14,358	$14,591	$24,000

ADVANCED ENERGY PROJECTS (Cont'd)

Percentage Breakdown by Performer

Laboratory	70%	70%	41%
University	19%	19%	11%
Industrial/Other	11%	11%	48%
Subtotal	100%	100%	100%
Number of Researchers Supported	145	145	150

I. Preface: ENERGY BIOSCIENCES

In the near future, biomass, a renewable resource, will assume an increasingly important role with respect to providing fuels, chemicals, and new materials as replacements for currently used fossil reserves. The research focus of the Energy Biosciences (EB) subprogram is to understand the fundamental mechanisms of how plants produce biomass and the mechanisms of biological transformation of crude, abundant biomass into other usable forms. The program provides the basic foundation for the broad exploitation of new sophisticated knowledge in molecular genetics. Currently, a major obstacle to the employment of exceedingly powerful molecular biological technology is the meager biological information base for defining new processes and applications. The EB subprogram is designed to fill this critical information gap by the support of research in the plant and microbiological sciences. A principal thrust is to develop, in the broadest way possible, understanding at the genetic, biochemical and physiological levels of the diverse capabilities of organisms to metabolically synthesize chemical compounds. Included in this thrust is generation of a thorough understanding of the mechanisms available to organisms for the conversion of noxious or undesirable materials into less threatening species. Such information could be used in designing new clean-up biotechnologies. The EB subprogram specifically focuses on major classes of plant compounds such as carbohydrates and lignins, in terms of how they are produced, how they are degraded, and what opportunities exist for their biological modification. Many of the research areas covered by the EB subprogram have been neglected over the years. Applications to energy problems would be expected in the mid- to long-term time scale. The program is unique in the federal government; its major focus is on the potential biological solution of energy problems addressed at the fundamental level. These include photosynthesis, methanogenesis, fermentations, genetics of anaerobic organisms and others. The program interacts and coordinates with the Conservation and Renewable Energy program in DOE as well as USDA and NSF programs and is participating with those agencies in a three agency program to support plant science centers. Where feasible, interactions with industry are promoted.

II. A. Summary Table

Program Activity	FY 1989 Actual	FY 1990 Estimate	FY 1991 Request	% Change
Energy Biosciences.....	$ 20,374	$ 20,674	$ 20,200	- 2
Total, Energy Biosciences....	$ 20,374	$ 20,674	$ 20,200	- 2

ENERGY BIOSCIENCES (Cont'd)

II. B. Major Laboratory and Facility Funding

Brookhaven National Laboratory.	$ 1,145	$ 970	$ 925	- 5
Lawrence Berkeley Laboratory...	1,253	1,100	1,101	0
Michigan State University.....	2,510	2,550	2,600	+ 2

III. Activity Descriptions

ENERGY BIOSCIENCES

Program Activity	FY 1989	FY 1990	FY 1991
Energy Biosciences	This level allowed continuation of the base program in plant and microbial sciences with internal adjustments of the program based on the turnover of projects. Some additional activity in plant biochemistry related to the mechanisms and regulation of the synthesis of lignin and plant and microbial polysaccharides was done with funds redirected from other research areas. Research activities on the biological modification of materials sponsored jointly with the Division of Materials Science was modestly increased. The multidisciplinary plant science center research activities initiated in FY 1987 on complex carbohydrates and in FY 1988 on the early events involved in photosynthesis continued to be supported. Congressional direction to support programs at the Oregon Graduate Center continued.	Efforts will be made to focus new projects in the areas of carbohydrate and lignin structure function synthesis and biodegradation. Ongoing research in these areas will, for the most part continue. The three agency (NSF-DOE-USDA) multidiciplinary plant science research centers begun in previous years at the University of Georgia and Arizona State University will be maintained. Congressional direction to support a program at the Oregon Graduate Center continues.	This is an essentially level budget for the Energy Biosciences subprogram in the plant and microbial sciences. It allows maintenance of strong projects and initiation of a few projects strictly dependent on the termination of others. The three agency (USDA-DOE-NSF) Plant Science Centers currently underway will continue to be supported.

III. ENERGY BIOSCIENCES (Cont'd)

Program Activity	FY 1989	FY 1990	FY 1991
Energy Biosciences (Cont'd)	No activity	Implementation plans for the Energy Sciences Network (ESNET) project identified in the Applied Mathematical Sciences subprogram will proceed. This subprogram's share for the implementation of ESNET is $25.	Upgrades of ESNET to conform to the National Research and Education Network standards will continue to be pursued and will be shared among ER programs that benefit from ESNET.
Total Energy Biosciences Operating Expenses	$20,374	$20,674	$20,200
Percentage Breakdown to Performer			
Laboratory	16%	16%	16%
University	82%	82%	82%
Industrial/Other	2%	2%	2%
Subtotal	100%	100%	100%
Number of Researchers Supported	195	195	195

I. Preface: PROGRAM DIRECTION

This subprogram provides the Federal staffing resources and associated funding required to develop, direct, and administer a complex and broadly diversified program for mission-oriented research to provide the fundamental scientific and engineering base on which the Nation's future energy, defense, and technology options depend. This staff supports basic research which helps us attain our national goals, i.e., better health and quality of life, economic competitiveness, energy self-sufficiency, and national security.

PROGRAM DIRECTION (Cont'd)

II. A. Summary Table

Program Activity	FY 1989 Actual	FY 1990 Estimate	FY 1991 Request	% Change
Program Direction.....	$ 4,900	$ 5,374	$ 6,500	+ 21
Total, Program Direction...	$ 4,900	$ 5,374	$ 6,500	+ 21

III. Activity Descriptions

PROGRAM DIRECTION

Program Activity	FY 1989	FY 1990	FY 1991
Program Direction	Provided funds for salaries, benefits, and travel for 64 full-time equivalents (FTE's) in the Office of Basic Energy Sciences, the Scientific Computing Staff, and related program and management support staff. Ongoing activities include assessing the scientific needs and priorities of the program; planning to meet those needs; technical review of proposals from laboratories and universities; and monitoring the progress of ongoing university contracts; laboratory programs, and construction projects; as well as responding to the many day-to-day requirements involving budget, procurement and other management support activities. Provided staff support for basic research, R&D and	Provide funds for salaries, benefits, and travel for 63 FTE's included in the FY 1990 budget including normal increased personnel costs. A revised request for seven additional FTE's follows. Four of the additional FTE's are required by line management for increased activities to ensure compliance with ES&H directives and regulations at numerous research facilities and to manage other programmatic workloads. Appraise contractor ES&H performance and ensure safe disposal of spent fuels and other byproducts and wastes. Manage increased user facilities construction, such as the 6-7 GeV project, and operation and increasing workloads in basic research programs in such areas as hydrocarbon, plant	Provide funds for salaries, benefits, and travel related to 70 FTE's. The increased funding will provide for seven additional FTE's over the FY 1990 budget level as discussed in FY 1990. Will also provide for normal increased personnel costs resulting, for example, from within-grade and merit increases and the impact of the FY 1990 general and executive pay raises. Continue to support National research goals supporting the country's energy-related technology foundation. In addition to enhanced support for ES&H and facilities R&D and construction, the additional staff will provide increased management oversight to maintain technical excellence in R&D in such areas as superconductivity, molecular

III. PROGRAM DIRECTION (Cont'd)

Program Activity	FY 1989	FY 1990	FY 1991
Program Direction (Cont'd)	facilities needed to continue U.S. leadership in key scientific areas and for numerous university construction projects. Addressed escalating environment, safety and health (ES&H) issues as they pertained to current and planned program facilities including two Class A reactors at Brookhaven and Oak Ridge National Laboratories and a new multimillion dollar research reactor still in the R&D phase; supported the Basic Energy Sciences Advisory Committee; and provided liaison with industry in such areas as superconductivity, semiconductors, and oil and gas geosciences. Also managed the DOE-wide SBIR program and the Magnetic Fusion Energy Computer Network. ($4,168)	chemical processes and semiconductor research. Three additional FTE's are also required to enhance the Office of Energy Research's independent ES&H oversight capability to provide support for responsibilities involving nuclear safety, health physics, occupational safety and industrial hygiene, environmental protection, hazardous waste management, safeguards and security, emergency preparedness, and quality assurance. Staff will perform safety appraisals, environmental compliance audits, and oversee interagency agreements. ($4,844)	supporting oil and gas and coal chemistry. Staff will continue to manage preconstruction R&D and construction of advanced scientific facilities and support numerous current user facilities. Interact significantly with other agencies on National efforts such as superconductivity and supercomputing. Continue to support projects maintaining scientific excellence which are relevant to DOE's long-term goals and help maintain world leadership in science and technology. ($5,955)
	Provided a variety of program support such as electronic information and communications services, printing and binding, and contractual services, for example, for the SBIR program and to assist with the environment, safety and health workload required by current regulations and directives. ($732)	Continue the variety of program support required in FY 1989. ($530)	Continue the variety of program support required in FY 1990. ($545)
Total, Program Direction	$4,900	$5,374	$6,500

I. Preface: CAPITAL EQUIPMENT

Capital equipment is needed to support the research in each of the subprograms in the Basic Energy Sciences program. In addition, Argonne and Ames are funded for general purpose equipment through BES for the purpose of providing all the DOE programs at ANL and Ames and with this type of equipment. Studies done both by the Department and by the laboratories continue to stress the importance of modernization in order to take advantage of technologically more efficient and safe instruments and equipment. Much of the research in the BES program involves experiments at extremes of temperature and pressure and requires unprecedented levels of resolution. Reliable, precise measurements under such conditions challenge the current state-of-the-art, and as improvements are made in instruments and equipment, it is important to benefit from them in a timely fashion. The quality of individual research projects and effective experiments at the major facilities depends on the availability of new state-of-the-art equipment and instrumentation, and on replacement of older, obsolete equipment.

II. A. Summary Table

Program Activity	FY 1989 Actual	FY 1990 Estimate	FY 1991 Request	% Change
Capital Equipment.....	$ 31,700	$ 36,486	$ 37,019	+ 1

III. Activity Descriptions

CAPITAL EQUIPMENT

Program Activity	FY 1989	FY 1990	FY 1991
Capital Equipment	Equipment needs were accommodated at the FY 1988 level. Replacement and acquisition of new equipment continued to ensure that optimum research results were obtained and properly analyzed. General purpose equipment requirements for Ames and ANL were met.	Equipment needs will be accommodated at the FY 1989 level. Replacement and acquisition of new equipment will continue to ensure that optimum research results can be obtained and properly analyzed. General purpose equipment requirements for Ames and ANL will continue to be met. Special equipment needs in Materials Sciences in superconductivity and semiconductor research areas will	Equipment needs will be accommodated at the current level. Replacement and acquisition of new equipment required will continue to ensure that optimum research results can be obtained and properly analyzed. General purpose equipment requirements for Ames and ANL will continue to be met.

III. CAPITAL EQUIPMENT (Cont'd)

Program Activity	FY 1989	FY 1990	FY 1991
Capital Equipment (Cont'd)		receive a small but needed increase. In addition, equipment necessary to expand research in molecular sciences is provided.	
Total, Capital Equipment	$31,700	$36,486	$37,019

I. Preface: CONSTRUCTION

Construction is needed to support the research in each of the subprograms in the Basic Energy Sciences program. Experiments necessary in support of basic research require that new state-of-the-art facilities be built and modified to meet unique research requirements. Reactors, radiation sources, and neutron sources are among the expensive, but necessary, facilities required. The budget for the BES program includes funding for the construction and modification of these facilities.

II. A. Summary Table

Program Activity	FY 1989 Actual	FY 1990 Estimate	FY 1991 Request	% Change
Construction.....	$ 86,621	$ 76,833	$108,034	+ 41

III. Activity Descriptions

CONSTRUCTION

Program Activity	FY 1989	FY 1990	FY 1991
Construction	Continues all projects under way in FY 1988 and makes provision for the start of design for the 6-7 GeV Synchrotron Radiation Source at ANL. Includes funding for several Congressionally- mandated projects.	Continues funding for AIP, GPP, 1-2 GeV, the 3 GeV Injector and the 6-7 GeV projects. The funding level in FY 1990 is less than the FY 1989 level because no provision is made for continuing funding for Congressionally-mandated university projects and funding for the LANSCE facility is completed in FY 1989.	Continues all projects underway in FY 1990, except for the 3 GeV which was completed.
Total Construction	$86,621	$76,833	$108,034

I. Preface: SUMMARY OF MAJOR USER FACILITIES

The major facilities discussed below are used to conduct forefront research in materials, chemistry, biology, medicine, semiconductors and in both the applied and basic sciences using lasers and high fluxes of neutrons or photons. These facilities are unique in their ability to probe the structure and properties of important energy related phenomena. In view of the expensive and unique character of these facilities, researchers from all parts of the Nation travel to these facilities to conduct their research, including researchers from government laboratories, industry and universities, in addition to DOE contractors. In addition to currently operating facilities, recommendations from national committees and DOE committees have identified needs for advanced facilities in order to continue to conduct leading edge research. The Department is requesting construction and research and development in FY 1991 for two advanced scientific facilities (1-2 GeV Synchrotron Light Source and the 6-7 GeV Synchrotron Radiation Source).

Summarized below is a list of each of these facilities, as well as a description of the activities underway in FY 1989, FY 1990 and FY 1991 to provide for their operation and maintenance. Funding for these facilities is included as part of the budget request in the Materials Sciences and Chemical Sciences subprograms.

SUMMARY OF MAJOR USER FACILITIES (Cont'd)

II. Summary Table

Program Activity	FY 1989 Actual	FY 1990 Estimate	FY 1991 Request		% Change
National Synchrotron Light Source	$ 19,324	$ 20,119	$23,766		+ 18
High Flux Beam Reactor	14,565	14,749	23,500	8.8	+ 59
Intense Pulsed Neutron Source	5,122	5,360	6,489		+ 21
High Flux Isotope Reactor	18,977	17,920	24,441	6.5	+ 36
Radiochemical Engineering Development Center	7,113	6,850	6,850		0
Stanford Synchrotron Radiation Laboratory	10,152	10,437	13,981		+ 34
Manuel Lujan, Jr. Neutron Scattering Center	4,800	4,437	5,700		+ 28
Combustion Research Facility	3,475	3,619	4,475		+ 24
Advanced Scientific Facilities					
1-2 GeV	1,873	5,548	10,891	+ 5.4	+ 96
6-7 GeV	5,822	9,441	14,852	+ 5.4 26.1	+ 57
Total Operating Expenses	$ 91,223	$ 98,480	$ 134,945	+36.4	+ 37

THE NATIONAL SYNCHROTRON LIGHT SOURCE (NSLS), BROOKHAVEN NATIONAL LABORATORY

The National Synchrotron Light Source is a unique user oriented facility for advanced research with synchrotron radiation. At NSLS a wide range of research techniques are used by biologists, chemists, solid state physicists, metallurgists, and engineers for basic and applied studies. This is a forefront dedicated facility which is used for vacuum ultra-violet and X-ray scattering and spectroscopy. The facility will be fully utilized in FY 1990.

Program Activity	FY 1989	FY 1990	FY 1991
NSLS	Continued full year operations with increase needed to accommodate user support.	Continue full year of operations.	Continue full year of operations with increase needed to accommodate user support and fully utilize facility.
Subtotal NSLS Operating	$19,324	$20,119	$23,766

III. SUMMARY OF USER MAJOR FACILITIES (Cont'd)

THE HIGH FLUX BEAM REACTOR (HFBR), BROOKHAVEN NATIONAL LABORATORY

The High Flux Beam Reactor produces high flux neutron beams used for research in a variety of fields. Neutrons are used as probes by nuclear and solid-state physicists, chemists, and biologists. This 20 year old research reactor has been a pacesetting facility and remains fully utilized and productive. About 200 users were involved in FY 1989. The scientific activity will continue at a constant level of effort during the next 2 years.

Program Activity	FY 1989	FY 1990	FY 1991
HFBR	Continued support with reduced number of operating cycles in order to accommodate completion of safety assessments identified by the NAS. The full extent of the safety improvements identified by the NAS are currently being determined.	Restores operation and accommodates increased costs of safety and heavy water requirements at the reactor. The full extent of the safety improvements identified by the NAS are currently being determined.	Continues full operation, safety improvements implemented. Funds are provided for uranium conversion, enrichment costs, and heavy water costs at HFBR.
Subtotal HFBR Operating	$14,565	$14,749	$23,500

THE INTENSE PULSED NUETRON SOURCE (IPNS), ARGONNE NATIONAL LABORATORY

The Intense Pulsed Neutron Source is a dedicated user facility for advanced research with pulsed neutrons serving the physics, materials, chemical, and life sciences research communities. It is fully utilized to the extent available. About 180 users were involved in FY 1989. With the planned improvements of the proton target source of neutrons and some of the spectrometers, the scientific activity at this facility will increase moderately during the next 2 years.

Program Activity	FY 1989	FY 1990	FY 1991
IPNS	Continued at FY 1988 level of operations for users.	Increases user support and operations above the FY 1989 level.	Continues full operation.
Subtotal IPNS Operating	$5,122	$5,360	$6,489

III. SUMMARY OF USER MAJOR FACILITIES (Cont'd)

THE HIGH FLUX ISOTOPE REACTOR (HFIR) AND RADIOCHEMICAL ENGINEERING DEVELOPMENT CENTER (REDC), OAK RIDGE NATIONAL LABORATORY

The High Flux Isotope Reactor is a multipurpose reactor which is used for the production of isotopes, and also used for materials sciences, nuclear chemistry, and radiation damage research. The isotopes are important to the research, medical, and industrial community. Many of these isotopes can only be produced at the HFIR reactor. When fully utilized about 150 users are involved with research at the facility. Currently, safety considerations have caused the reactor to remain down. The current DOE plan is to restart the reactor after it is determined that the reactor can be safely operated and necessary improvements in plant and personnel have been made. This includes the hiring of additional staff, modifications to the reactor, and additional training of the reactor staff. The Radiochemical Engineering Development Center, formerly the Transuranium Processing Plant, is a companion facility to the HFIR and was built to recover the transuranium elements from irradiated targets from the reactor. The combined operating costs of these facilities are shown below.

Program Activity	FY 1989	FY 1990	FY 1991
HFIR and REDC	REDC and HFIR facility improvements continued in order to address safety requirements necessary prior to the restart of the reactor.	REDC and HFIR facility improvements will proceed on a 12 month schedule. HFIR will be restarted to provide full services to users with safety upgrades mentioned above continued.	HFIR will operate 12 months and provide full services to users with safety, quality assurance and physical facility improvements proceeding as planned. REDC operations and improvements will be carried out for a full 12 months. Funds are provided for the highly enriched uranium needed for the HFIR fuel.
Subtotal HFIR/REDC Operating	$26,090	$24,770	$31,291

THE STANFORD SYNCHROTRON RADIATION LABORATORY (SSRL), STANFORD UNIVERSITY

The Stanford Synchrotron Radiation Laboratory is a national facility funded to permit the utilization of synchrotron radiation for basic and applied research in chemistry, physics, biology, and materials sciences. The operation of this facility is dependent on the operation of the High Energy Physics electron injector. When fully utilized about 500 users are involved in research at the facility. With some new beamlines being commissioned, increased scientific activity is expected. Construction of a separate 3 GeV electron injector for the SPEAR Ring will continue in FY 1990.

III. SUMMARY OF MAJOR USER FACILITIES (Cont'd)

Program Activity	FY 1989	FY 1990	FY 1991
SSRL	SSRL operations continued at approximately the same level as in FY 1988.	Operation of SSRL and PEP will be continued.	Full operations of SSRL as dedicated synchrotron facility with 3 GeV injector.
Subtotal SSRL Operating	$10,152	$10,437	$13,981

MANUEL LUJAN, JR. NEUTRON SCATTERING CENTER, LOS ALAMOS NATIONAL LABORATORY

The Manuel Lujan, Jr. Neutron Scattering Center is a dedicated user facility for advanced research with the nation's most intense pulsed neutrons serving the physics, materials, chemical, and life sciences research communities. The operation of this facility utilizes the Los Alamos proton storage ring facility and is budgeted by Defense Programs. Construction of a new experimental hall at the Center continued in FY 1988 and was completed in FY 1989. With the new experimental hall, the scientific program activity will involve, by FY 1991, nearly 100 materials and materials-related scientists.

Program Activity	FY 1989	FY 1990	FY 1991
Manuel Lujan, Jr. Neutron Scattering Center	Increased operations funding for user support.	Continues operations and user support at the FY 1989 level.	Increased funding for operations and user support.
Subtotal Operating	$4,800	$4,437	$5,700

COMBUSTION RESEARCH FACILITY (CRF), SANDIA NATIONAL LABORATORY

The Combustion Research Facility provides a unique capability to outside users from industry, university, and laboratory scientists for combustion research. The focus of the laboratory is on laser diagnostics of combustion systems, but a variety of burner systems and special facilities are available, including those for research on coal combustion and internal combustion engines. About 30 experiments involving about 50 scientists were operational in FY 1989. About one new experimental capability will be added each year for the next several years.

III. SUMMARY OF MAJOR USER FACILITIES (Cont'd)

Program Activity	FY 1989	FY 1990	FY 1991
CRF	Provided for needed increase in operations and user support over the FY 1988 level.	Operations will continue at the FY 1989 level.	The postdoctoral and visiting scientist program will be enhanced to facilitate "technology transfer." Shorter time laser pulses and enhanced computer capability will be available to users for advanced studies in dynamics.
Subtotal CRF Operating	$3,475	$3,619	$4,475

ADVANCED SCIENTIFIC FACILITIES

Funding in FY 1991 is requested to continue research and development activities associated with the two major scientific facilities proposed for construction in the program. These facilities are the 1-2 GeV Synchrotron Light Source (LBL) and the 6-7 GeV Synchrotron Radiation Source (ANL). Preconstruction R&D funds are requested to resolve technical uncertainties prior to and early in the actual construction of the facilities. In the case of the 1-2 GeV, construction is underway and the R&D funds for this project are focused on improvements to the magnet lattice and related activities. For the 6-7 GeV Source, significant R&D activities are necessary due to the overall size and complexity of the project. Research activities at the 6-7 GeV will be focused on prototypes of the dipole magnets and insertion devices.

Program Activity	FY 1989	FY 1990	FY 1991
Advanced Scientific Facilities	R&D funding for advanced scientific facilities continued.	Provides support for needed R&D for the 1-2 GeV and 6-7 GeV light sources. The increase in FY 1990 is required to begin to hire additional staff to ready the 1-2 GeV for operation and to meet the R&D schedule for the 6-7 GeV light source.	Provides for necessary increase to fully support R&D of the 1-2 and 6-7 GeV light sources. The increase provided helps ensure that the necessary R&D is completed to maintain the schedule and cost of these projects.
Subtotal Advanced Scientific Facilities Operating	$7,695	$14,989	$25,743

DEPARTMENT OF ENERGY
FY 1991 CONGRESSIONAL BUDGET REQUEST
ENERGY SUPPLY RESEARCH AND DEVELOPMENT
(dollars in thousands)

KEY ACTIVITY SUMMARY

CONSTRUCTION PROJECTS

Basic Energy Sciences

IV. Construction Project Summary

Project No.	Project Title	Total Prior Year Obligations	FY 1990 Appropriated	FY 1991 Request	Unappropriated Balance	TEC
91-E-314	Accelerator Improvements Projects	2,300	4,536	6,965	0	6,965
GPE-400	General Plant Projects	3,221	2,784	3,069	0	3,069
89-R-402	6-7 GeV Synchrotron Radiation Source	6,000	39,440	75,000	335,000	456,000
88-R-403	3 GeV Spear Injector	9,500	4,437	0	0	13,937
87-R-406	1-2 GeV Sychrotron Radiation Source	44,500	25,636	23,000	6,000	99,500
Total, Basic Energy Sciences Construction		XXX	76,833	108,034	341,000	XXX

DEPARTMENT OF ENERGY
FY 1991 CONGRESSIONAL BUDGET REQUEST
ENERGY SUPPLY RESEARCH AND DEVELOPMENT
(dollars in thousands)

KEY ACTIVITY CONSTRUCTION PROJECT SUMMARY

Basic Energy Sciences

IV. B. Plant Funded Construction Project

1. Project title and location: 91-E-314 Accelerator and reactor improvements and modifications, various locations

Project TEC: $ 6,965
Start Date: 2nd Qtr. FY 1991
Completion Date: 3rd Qtr. FY 1993

2. Financial Schedule:

Fiscal Year	Appropriated	Obligations	Costs
1991	$ 6,965	$ 6,965	$ 4,000
1992	0	0	2,000
1993	0	0	965

3. Narrative:

(a) This project provides for additions and modifications to accelerator and reactor facilities, which are supported by the Basic Energy Sciences program. Since program priorities and needs change, the projects described below indicate the most likely projects to be funded. A continuing evaluation, however, is necessary to ensure that those projects with the greatest productivity are funded. Two projects at the Brookhaven National Laboratory are requested to incorporate improvements at the High Flux Beam Reactor and the National Synchrotron Light Source, one project is requested for facility improvements at the Stanford Synchrotron Radiation Laboratory, one project is requested at the Oak Ridge National Laboratory for improvements to the High Flux Isotope Reactor, and one project is requested for facility improvements at the University of Notre Dame, Radiation Laboratory.

(b) The following are the projected items of work to be performed at the various locations. Since needs and priorities may change, other projects may be substituted for the examples listed below, and some of these may be located on non-Government owned property.

National Synchrotron Light Source
Component hardware replacements and additions to achieve improved orbit stability by elimination of noise sources and to provide active feedback systems.

High Flux Beam Reactor
New state-of-the-art instrumentation to provide improved reliability and maintainability, such as control rod position indicators, primary system instrumentation, and on-line secondary water tritium monitors.

Stanford Synchrotron Radiation Laboratory
Provide for improvements to the Stanford Synchrotron Radiation Laboratory necessary to meet changing research activities underway. Modifications to beam lines, enhanced monitoring, and evaluation equipment are among the types of improvements necessary at this laboratory.

High Flux Isotope Reactor

Provide for necessary safety improvements identified for the High Flux Isotope Reactor (HFIR) facilities and systems such as the confinement system, ventilation systems, confinement building, and auxiliary buildings.

Radiation Laboratory, University of Notre Dame

Provide for improvements in the Linear Accelerator Facility by augmenting the present accelerator with a technologically superior accelerator with substantially higher beam dosage, substantially better beam stability and reproducibility, and improved time resolution.

4. Total Project Funding (BA):

	FY 1991 Request
Construction	$ 6,965

DEPARTMENT OF ENERGY
FY 1991 CONGRESSIONAL BUDGET REQUEST
ENERGY SUPPLY RESEARCH AND DEVELOPMENT
(dollars in thousands)

KEY ACTIVITY CONSTRUCTION PROJECT SUMMARY

Basic Energy Sciences

IV. B. Plant Funded Construction Project

1. Project title and location: GPE-400 General plant projects

Project TEC: $ 3,069
Start Date: 1st Qtr. FY 1991
Completion Date: 4th Qtr. FY 1992

2. Financial schedule:

		Costs			
Fiscal Year	Obligations	FY 1989	FY 1990	FY 1991	After FY 1991
Prior Year Projects	4,900	2,897	0	0	0
FY 1989 Projects	3,221	1,671	1,550	0	0
FY 1990 Projects	2,784	0	1,400	1,384	0
FY 1991 Projects	3,069	0	0	739	2,330

3. Narrative:

(a) This project is required to provide for minor new construction, other capital alterations and additions, and for buildings and utility systems. Where applicable, the request also includes the cost of installed capital equipment integral to a subproject. Funding of this type is essential for maintaining the productivity and usefulness of Department-owned facilities. Since it is difficult to detail this type of project in advance, a continuing evaluation of requirements and priorities may be expected to result in additions, deletions, and changes in the currently planned subproject.

(b) The currently estimated distribution of FY 1990 funds by office is as follows:

Ames Laboratory	$ 648
Argonne National Laboratory	1,671
Notre Dame Radiation Laboratory	50
Sandia National Laboratories	350
Stanford Synchrotron Radiation Laboratory	350
Total project cost	$ 3,069

FY 1991 General Plant Projects (GPP) are miscellaneous minor new construction projects of a general nature. The total estimated costs of each will not exceed $1,200,000. These projects are necessary to provide for the continuing requirement to maintain the facilities in a good state of repair, to adapt the facilities to new or improved production or service techniques, to effect economics of operations and to reduce or eliminate health, fire, and security problems.

4. Total Project Funding (BA):

	Prior Years	FY 1989	FY 1990	FY 1991 Request
Construction	$ 4,900	$ 3,221	$ 2,823	$ 3,069

DEPARTMENT OF ENERGY
FY 1991 CONGRESSIONAL BUDGET REQUEST
ENERGY SUPPLY RESEARCH AND DEVELOPMENT
(dollars in thousands)

KEY ACTIVITY CONSTRUCTION PROJECT SUMMARY

Basic Energy Sciences

IV. B. Plant Funded Construction Project

1. Project title and location: 89-R-402 6-7 GeV Synchrotron Radiation Source
Argonne National Laboratory
Argonne, Illinios

Project TEC: $ 456,000
Start Date: 2nd Qtr. FY 1989
Completion Date: 3rd Qtr. FY 1996

2. Financial schedule:

Fiscal Year	Appropriated	Obligations	Costs
1989	$ 6,000	$ 6,000	$ 5,633
1990	39,440	39,440	35,000
1991	75,000	75,000	48,000
1992	92,560	92,560	109,000
1993	105,000	105,000	110,000
1994	93,000	93,000	97,000
1995	45,000	45,000	49,000
1996	0	0	2,367

3. Narrative:

(a) Argonne National Laboratory has completed a conceptual design for, and plans to design, construct, and operate, a new-generation 6-7 GeV synchrotron radiation source. This facility is important for the Department's research program and will serve as a national resource for the conduct of research by industry, government, and university scientists. This facility will produce unprecedentedly brilliant x-ray beams to serve the research needs of virtually all scientific disciplines and many technological fields, e.g., physics, chemistry, materials and surface science, biology, and medicine. Users will include scientists, engineers, and graduate students from universities, industry, and research laboratories throughout the United States.

(b) The facility as currently envisaged would consist of a large storage ring containing as many as 35 insertion devices to give intense beams of hard x-rays. The injection and booster systems would be designed to inject positrons into the storage ring at the design energy of 6-7 GeV. Beam currents as high as 100 milliamperes and lifetimes of at least 10 hours are anticipated. Most

importantly, the lowest possible beam emittance would be sought to give the highest brilliance x-ray source by a factor of 10,000 over any in existence. This facility would impact heavily on the fields of physics, materials, chemistry, biology and medicine, and many technologies. Determination of bulk and surface structure will be performed with greater resolution and accuracy. Microprobe characterization will allow impurity detection in the parts per billion range. The high brilliance will make possible inelastic x-ray scattering which is an essentially unexplored field. Investigating time-dependent phenomena in biological membranes and in photosynthetic processes will be possible, as will observing the motion of atoms in protein systems. Angiography and analysis of tumor diseases will be advanced through non-invasive and very fast x-ray diagnostics without, or with the minimal use of, dyes or drugs. Topography will be extended to time-resolved studies of plastic deformation and fracture. All of these investigations are made possible by the photon energy, time-structure, intensity, and unusual brilliance of the radiation source. Other experiments important to national security needs would also be undertaken.

4. Total Project Funding (BA):

	Prior Years	FY 1989	FY 1990	FY 1991 Request	To Complete
Construction	$ 0	$ 6,000	$39,440	$75,000	$335,560
Capital Equipment	2,300	500	1,000	1,000	4,000
Operating Expenses	15,000	5,822	10,500	15,500	125,300

DEPARTMENT OF ENERGY
FY 1991 CONGRESSIONAL BUDGET REQUEST
ENERGY SUPPLY RESEARCH AND DEVELOPMENT
(dollars in thousands)

KEY ACTIVITY CONSTRUCTION PROJECT SUMMARY

Basic Energy Sciences

IV. B. Plant Funded Construction Project

1. Project title and location: 87-R-406 1-2 GeV Synchrotron Radiation Source
Lawrence Berkeley Laboratory
Berkeley, California

Project TEC: $ 99,500
Start Date: 1st Qtr. FY 1987
Completion Date: 4th Qtr. FY 1992

2. Financial schedule:

Fiscal Year	Appropriated	Obligations	Costs
1987	$ 1,500	$ 1,500	$ 985
1988	18,000	18,000	10,317
1989	25,000	25,000	21,952
1990	25,636	25,636	30,050
1991	23,000	23,000	22,350
1992	6,364	6,364	13,846

3. Narrative:

(a) The 1-2 GeV Synchrotron will be built within the Lawrence Berkeley Laboratory, which is located on University of California property adjacent to the Berkeley campus. The project will include the construction of new facilities, and alterations and additions to existing plant and site facilities. The 1-2 GeV Synchrotron is a special facility comprised of an electron storage ring and injection system, insertion devices (undulators and wigglers) for generating synchrotron radiation and photon beamlines.

(b) The 1-2 GeV Synchrotron Facility will be a dedicated synchrotron radiation source that is optimized for generating vacuum ultraviolet (VUV) and soft x-ray (XUV) light from periodic magnetic devices. Investigators from industry, universities, and national laboratories will have access to unique capabilities--high spectral brilliance and very short pulse length (nominally tens of picoseconds). This brilliance makes possible new studies in both basic and applied science including: 1) materials and surface science; 2) atomic and molecular physics; 3) chemistry; 4) biology; 5) industrial utilization; and 6) areas of national security.

4. Total Project Funding (BA):

	Prior Years	FY 1989	FY 1990	FY 1991 Request	To Complete
Construction	$19,500	$25,636	$25,636	$23,000	$ 6,364
Capital Equipment	1,000	1,000	1,500	1,000	1,000
Operating Expenses	3,500	1,873	6,000	11,000	18,600

DEPARTMENT OF ENERGY
FY 1991 CONGRESSIONAL BUDGET REQUEST
CONSTRUCTION PROJECT DATA SHEETS
ENERGY SUPPLY RESEARCH AND DEVELOPMENT - PLANT AND CAPITAL EQUIPMENT
BASIC ENERGY SCIENCES
(Tabular dollars in thousands. Narrative material in whole dollars.)

1. Title and location of project: Accelerator and Reactor Improvements and Modifications, various locations

2. Project No.: 91-E-314

3. Date A-E work initiated: 2nd Qtr. FY 1991

3a. Date physical construction starts: 3rd Qtr. FY 1991

4. Date Construction ends: 3rd Qtr. FY 1993

5. Previous cost estimate: none

6. Current cost estimate: $ 6,965
Less amount for PE&D: 0
Net cost estimate: $ 6,965
Date: December 1989

7. Financial Schedule

Fiscal Year	Authorization	Appropriations	Obligations	Costs
1991	$6,965	$6,965	$6,965	$4,000
1992	0	0	0	2,000
1993	0	0	0	965

8. Brief Physical Description of Project

This project provides for additions and modifications to accelerator and reactor facilities, which are supported by the Basic Energy Sciences program. Since program priorities and needs change, the projects described below indicate the most likely projects to be funded. A continuing evaluation, however, is necessary to ensure that those projects with the greatest productivity are funded. Two projects at the Brookhaven National Laboratory are requested to incorporate improvements at the High Flux Beam Reactor and the National Synchrotron Light Source, one project is requested for facility improvements at the Stanford Synchrotron Radiation Laboratory, one project is requested at the Oak Ridge National Laboratory for improvements to the High Flux Isotope Reactor, and one project is requested for facility improvements at the University of Notre Dame, Radiation Laboratory.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: Accelerator and Reactor Improvements and Modifications, various locations

2. Project No.: 91-E-314

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

The following are the projected items of work to be performed at the various locations. Since needs and priorities may change, other projects may be substituted for the examples listed below, and some of these may be located on non-Government owned property.

a. National Synchrotron Light Source

Beam stability at the NSLS is sensitive to vibration. The HFBR has a reciprocating gas helium compressor in operation which causes beam instability at the NSLS. A screw type compressor will eliminate this particular vibration source.

The X17 beamline is being constructed with white beam capabilities. It will require a monogrammatic for the completion of its design goals. The device will have to handle large thermal loading and focus high energy radiation.

The ring power supplies, especially the RF system, are susceptible to input power phase and amplitude interruptions. One or certainly two missing AC cycles will cause the beam to dump. These conditions occur during thunderstorms or changes in system loading when turbines are switched in or out. In addition the AC voltage flicker produced by the AGS booster magnets will cause beam motion. A transformer would protect against the vagaries of the LILCO power grid.

A high power high efficiency monochromator is necessary to accomplish advanced photoemission microscopy. The X1 monochromator will be high efficiency conical diffraction grading with state-of-the-art water cooling.

There are two critical components needed to complete the X21 inelastic X-ray scattering beamline. These are the purpose built spectrometer for the experiment and a cooled pre-monochromator that is placed upstream of the high resolution monochromator. The design of the components will rely heavily on experience gained on X25 and early tests on the X21.

1. Title and location of project: Accelerator and Reactor Improvements and Modifications, various locations

2. Project No.: 91-E-314

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

The X-ray front end status monitor system will allow the operator and central control computer to determine the security and utilization status of all beamlines. The system will automatically read the vacuum pressure at the storage rings front ends and also display the residual gas analyzer's readings and improve ring performance. The AC line variation appear to be causing orbit shift. In both the UV and X-ray rings the stability of the circulating beam orbit is critical. This line monitor will permit measurements to verify the influence of orbit by A/C line variations.

This project will consist of investigating the minimum gap limitations for an insertion magnet installed in the X-ray Ring and construction of the small gap magnet for specialized synchrotron radiation research. A present need also exists for high flux undulator sources for certain synchrotron radiation research in the region between 1 MeV and 6 MeV. The small gap magnet will make an excellent source for this research.

The ten year old booster magnet supplies (dipole, quadrupole, and sextupole) presently run at a frequency of 0.67 Hz. Proposed new supplies for these magnets will increase the booster repetition rate to 2 Hz with an order of magnitude improvement in ripple and stability, resulting in higher charge transfer capability, i.e., higher injection rates for the storage rings.

The Superconducting wiggler system began operation in FY 1989. The NSLS refrigeration/liquefaction plant that supports the operation has no gas recovery system. Quenching of the SCW will generate a large volume of helium gas that would otherwise be vented into the atmosphere without this system.

Numerous components inside the UHV domain are made of copper alloy. Proper cleaning procedures prior to the joining operation and installation into the UHV domain are required to assure satisfactory performance. The copper cleaning facility will be accomplished with modifications to the existing cleaning facility.

Many experiments require cooling samples to low temperatures. A displex system for x-ray experiments will accomplish this need.

1. Title and location of project: Accelerator and Reactor Improvements and Modifications, various locations

2. Project No.: 91-E-314

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

The existing Booster trim power supplied cannot be ramped with Booster rate. The new power supplied will have a faster response time and will be able to ramp with the Booster rate.

The regulation and the reliability of the present power supplies are inadequate. All power supplies will be replaced with 'state of the art' power supplies. The power supplies will have better regulation and more reliable.

b. High Flux Beam Reactor

The shutdown cooling water pumps are important components of the emergency core cooling systems. As a result of the redundant power supply systems to these pump motors, transfer switches are required to allow the motors to seek the available power. This project will replace the existing transfer switches with state-of-the-art emergency transfer switches and eliminate the maintenance requirements which continue to increase.

The present safety relief valve system on the poison water tank consists of a single hard seated valve. Periodic testing is performed to show operability and leak tightness. This project will replace the present valve with two interchangeable soft seated valves and will allow bench testing and replacement. Loss of programmatic time due to unscheduled maintenance on the single valve will be avoided.

Wiring to the control rod drive units, including power and instrumentation, is in a high radiation field. Insulation embrittlement hampers maintenance operations and results in secondary maintenance requirements following mechanical maintenance on control rod drives. This project would replace the present direct wiring system with a terminal board/quick disconnect system. This improvement will reduce maintenance time in this high radiation area, improve the work environment by relieving congestion in the area, and allow easier replacement of wiring as it approaches its lifetime in this severe environment.

An assessment of access limitations to several areas of the HFBR posed by a representative range of postulated accidents has indicated a need for an extension of the remote monitoring system. At present, the

1. Title and location of project: Accelerator and Reactor Improvements and Modifications, various locations

2. Project No.: 91-E-314

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

remote controls and viewing screen for the monitoring system is only located in the HFBR lobby. This project will expand the remote monitoring system to allow for complete operating capabilities at the HFBR Tech. Support Center in Building 703.

Upgrade Light Water Purification and Fuel Pool System - this project will replace the present light water purification system and introduce a new powdered resin filter in the fuel pool system. The result will be the elimination of all regenerative water as a liquid radioactive waste. The powdered resin waste will be reclaimed as a solid waste within the HFBR. Treatment and disposal of solid waste will be less expensive and present a reduced environmental impact when compared to liquid waste.

The instruments currently used to monitor the Cold Neutron Facility (CNF) moderator, helium compressor and refrigerator are not on automatic logging equipment. During the startup of the helium compressor/refrigerator it takes approximately ten minutes to take an instrument log. Therefore it is impossible to determine out-of-normal conditions of very small magnitudes for diagnostic purposes. This package will upgrade most of the instruments in the building 751 to electronic analog outputs that a data logger can record. It will also allow continuous monitoring of these instruments in building 751 and 750. Should an out-of-normal range condition occur, the automatic dialer will inform someone so the condition can be corrected prior to a CNF vent and purge.

c. Stanford Synchrotron Radiation Laboratory

This project will provide for improvements at the Stanford Synchrotron Radiation Laboratory necessary to meet changing research activities underway. The capabilities at this laboratory are an essential part of several BES research efforts, and to meet these unique requirements, modifications and improvements are necessary. Modifications to beam lines, enhanced monitoring, and evaluation equipment are among the types of improvements necessary at this laboratory.

d. High Flux Isotope Reactor

The purpose of this project is to improve the safety of the HFIR and to assure compliance with DOE orders and with applicable standards, codes and regulations.

1. Title and location of project: Accelerator and Reactor Improvements and Modifications, various locations

2. Project No.: 91-E-314

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

The HFIR is needed for isotope production, neutron scattering experiments, and irradiation services. Isotopes produced in the HFIR are used extensively in medical and industrial application. The HFIR is the major source of transuranic elements for researchers in the free world. Neutron scattering facilities at the HFIR are used for fundamental research in materials science. The neutron scattering facilities are available to the DOE community and academic and industrial users. Experiments to be conducted at the HFIR will aid design of the proposed Advanced Neutron Source. Neutron irradiation services are of benefit to the High Temperature Gas-Colled Reactor (HTGR) program through irradiation of fuels and graphite and to the Fusion Energy program through materials irradiations.

e. Radiation Laboratory, University of Notre Dame

This project will provide for improvements in the Linear Accelerator Facility by augmenting the present accelerator with a technologically superior accelerator with substantially higher beam dosage, substantially better beam stability and reproducibility, and improved time resolution.

10. Details of Cost Estimate

a.	High Flux Beam Reactor Facility	$ 530
b.	National Synchrotron Light Source	2,500
c.	Stanford Synchrotron Radiation Laboratory	535
d.	High Flux Isotope Reactor	2,800
e.	Notre Dame	600
	Total Project Cost	$6,965

11. Method of Performance

Design, engineering and inspection will be performed by Brookhaven National Laboratory, Stanford Synchrotron Radiation Laboratory, Oak Ridge National Laboratory, and University of Notre Dame. To the extent feasible, construction and procurement will be accomplished by fixed-price contracts and subcontracts awarded on the basis of competitive bidding.

DEPARTMENT OF ENERGY
FY 1991 OMB CONGRESSIONAL BUDGET REQUEST
CONSTRUCTION PROJECT DATA SHEETS
ENERGY SUPPLY RESEARCH AND DEVELOPMENT - PLANT AND CAPITAL EQUIPMENT
BASIC ENERGY SCIENCES
(Tabular dollars in thousands. Narrative material in whole dollars.)

1. Title and location of project: General Plant Projects

2. Project No.: GPE-400

3. Date A-E work initiated: 1st Qtr. FY 1991

3a. Date physical construction starts: 2nd Qtr. FY 1991

4. Date construction ends: 4th Qtr. FY 1992

5. Previous cost estimate: None

6. Current cost estimate: $1,398
Date: December 1989

7. Financial Schedule:

Fiscal Year	Obligations	Costs FY 1989	Costs FY 1990	Costs FY 1991	Costs FY 1992
Prior Year Projects	$ 4,900	$ 2,897	$ 0	$ 0	$ 0
FY 1989 Projects	3,221	1,671	1,550	0	0
FY 1990 Projects	2,784	0	1,400	1,384	0
FY 1991 Projects	3,069	0	0	739	2,330

8. Brief Physical Description of Project

This project is required to provide for minor new construction, other capital alterations and additions, and for buildings and utility systems. Where applicable, the request also includes the cost of installed capital equipment integral to a subproject. Funding of this type is essential for maintaining the productivity and usefulness of Department-owned facilities. Since it is difficult to detail this type of project in advance, a continuing evaluation of requirements and priorities may be expected to result in additions, deletions, and changes in the currently planned subproject. In general, the estimated funding for each location is preliminary in nature, and is intended primarily to indicate the relative magnitude of the requirements. No significant R&D program is anticipated as a prerequisite for design and construction of the subprojects under construction.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: General Plant Projects — 2. Project No.: GPE-400

8. Brief Physical Description of Project (continued)

The currently estimated distribution of FY 1991 funds by office is as follows:

Ames Laboratory	$ 648
Argonne National Laboratory	1,671
Notre Dame Radiation Laboratory	50
Sandia National Laboratories	350
Stanford Synchrotron Radiation Laboratory	350
Total project cost	$ 3,069

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

The following are examples of the major items to be performed at the various locations. Since needs and priorities may change, other projects may be substituted for the examples listed below, and some of these may be located on non-Government owned property.

Ames Laboratory..... $ 648

The major projects are Spedding Hall addition, asbestos removal and insulation replacement modification of Development Building Freight elevator for handicapped operation, and initiation of Phase III of Wilhemn Hall HVAC upgrade. The balance of the work involves handicapped access, environmental, energy conservation and general construction items.

The projects described above will be constructed on the Ames Laboratory, non-Government owned property.

Argonne National Laboratory..... $ 1,671

The Argonne National Laboratory FY 1991 General Plant Projects (GPP) are miscellaneous minor new construction projects of a general nature. The total estimated costs of each will not exceed $1,200,000. These general plant projects are necessary to provide for the continuing requirement to maintain the facilities in a good state of repair, to adapt the facilities to new or improved production or service techniques, to effect economics of operations and to reduce or eliminate health, fire, and security problems. The highest priority projects will be selected as needs are identified in FY 1991.

1. Title and location of project: General Plant Projects — 2. Project No.: GPE-400

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

Of the total requested for GPP at the Argonne National Laboratory, approximately 50 percent will be used for plant rehabilitation and approximately 50 percent will be used for upgrading and programmatic projects.

Notre Dame Radiation Laboratory..... $ 50

Requirements include environmental and safety improvements as well as general maintenance requirements such as the replacement of the roof on the Radiation Laboratory Building, which is a Government-owned facility located on non-Government owned property.

Sandia National Laboratories..... $ 350

The Combustion Research Facility (CRF) at Sandia National Laboratories, Livermore (SNLL) has a continuing need for General Plant Project (GPP) funds for upgrading or the construction of facilities as required to meet expanding or changing programmatic goals. Some experiments, both active and proposed, have become increasingly complex and consequently require larger laboratory space than is currently available to them. The GPP funding in this request will provide additional laboratory space with appropriate modifications to suit individual experimental situations.

Stanford Synchrotron Radiation Laboratory..... $ 350

Requirements include minor modifications and additions necessary to support the optimum use of the laboratory research capabilities. These improvements are necessary to maintain the capital investment at the site and to accommodate the continuous changes to the physical site necessitated by the evolving SSRL research program. Examples include upgrading of laboratory space, modifications to roads and parking areas, and relocation of experimental equipment at the facility. The projects described will be constructed at the Stanford University, non-Government owned property.

10. Details of Cost Estimate

See description, item 8. The estimated costs are preliminary and, in general indicate the magnitude of each program. These costs included engineering, design, construction and inspection.

1. Title and location of project: General Plant Projects | 2. Project No.: GPE-400

11. Method of Performance

Design will be on the basis of negotiated architect-engineer contracts. To the extent feasible, construction and procurement will be accomplished by firm fixed-price contracts and subcontracts awarded on the basis of competitive bidding.

DEPARTMENT OF ENERGY
FY 1991 CONGRESSIONAL BUDGET REQUEST
CONSTRUCTION PROJECT DATA SHEETS
ENERGY SUPPLY RESEARCH AND DEVELOPMENT - PLANT AND CAPITAL EQUIPMENT
BASIC ENERGY SCIENCES
(Tabular dollars in thousands. Narrative material in whole dollars.)

1. Title and location of project: 6-7 GeV Synchrotron Radiation Source
Argonne National Laboratory
Argonne, Illinois

2. Project No.: 89-R-402

3. Date A-E work initiated: 2nd Qtr. FY 1989

3a. Date physical construction starts: 3rd Qtr. FY 1990

4. Date construction ends: 3rd Qtr. FY 1996

5. Previous cost estimate: $456,000
Date: January 1989

6. Current cost estimate: $456,000
Date: December 1989

7. Financial Schedule:

Fiscal Year	Authorization	Appropriations	Obligations	Costs
FY 1989	$ 6,000	$ 6,000	$ 6,000	$ 5,633
FY 1990	39,440	39,440	39,440	35,000
FY 1991	75,000	75,000	75,000	48,000
FY 1992	92,560	92,560	92,560	109,000
FY 1993	105,000	105,000	105,000	110,000
FY 1994	93,000	93,000	93,000	97,000
FY 1995	45,000	45,000	45,000	49,000
FY 1996	0	0	0	2,367

8. Brief Physical Description of Project

The DOE has selected the Argonne National Laboratory to conduct research and complete a conceptual design of a new generation 6-7 GeV synchrotron radiation source. This facility is important for the Department's research program and will serve as a national resource for the conduct of research by industry, government, and university scientists. This facility will be located at the Argonne National Laboratory and will produce unprecedentedly brilliant x-ray beams to serve the research needs of virtually all scientific disciplines and

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: 6-7 GeV Synchrotron Radiation Source
Argonne National Laboratory
Argonne, Illinois

2. Project No.: 89-R-402

8. Brief Physical Description of Project (continued)

many technological fields, e.g., physics, chemistry, materials and surface science, biology, and medicine. Users will include scientists, engineers, and graduate students from universities, industry, and research laboratories throughout the United States.

The accelerator complex will consist of a 200 MeV electron accelerator, a positron production target, a positron linac, a positron accumulator ring, an injector synchrotron to accelerate positrons to 6-7 GeV, and a positron storage ring. The storage ring will be housed in an annular building and will provide space for more than 80 experimental beamlines and related equipment. Funding for an initial complement of beamlines is included in this construction project. The injector synchrotron will be housed in a separate, but related, structure. The complex will also include: offices; general and special purpose laboratories; clean room laboratories; and miscellaneous service operations areas. Provisions are included for site access roads, parking, service utilities, and miscellaneous site amenities.

The central lab/office building will contain laboratories, administrative offices, a control room, computer rooms, library and technical areas with an associated multiuse meeting facility.

The following is a brief physical description of the project facilities:

TECHNICAL COMPONENTS: The major system components for the production and injection of positrons are of conventional design. The storage ring, with approximately a 1100-meter circumference and 40 6-meter-long straight sections, is so designed that the positron beam size and position at each insertion device can be tuned independently for optimal performance. Storage ring magnets are of conventional design; however, a novel and highly effective vacuum system is proposed. The storage ring will operate at an energy (6-7 Gev) which will assure that 20 keV x-rays can be effectively obtained from an undulator in the fundamental mode.

Of the 40 straight sections, 6 will be occupied by accelerator equipment. Thus a total of 34 straight sections are available for insertion devices (undulators and wigglers). In addition, 35 photon beams from bending magnets (BM) can be provided. The initial compliment of beamlines included directly in the project are based on three different types of radiation sources. Additional beamlines, as provided through Participating Research Teams (PRTs), are also expected to be ready at commissioning.

1. Title and location of project: 6-7 GeV Synchrotron Radiation Source
Argonne National Laboratory
Argonne, Illinois

2. Project No.: 89-R-402

8. Brief Physical Description of Project (continued)

CONVENTIONAL FACILITIES: The central laboratory and office building is a conventionally designed building with structural steel framing, concrete floor slabs, and an architectural metal exterior curtain wall with insulated glass windows. The office/laboratory section is three stories high, while the adjoining support wing areas are one story high which forms a "Y" shaped building footprint. An adjacent building houses a multipurpose meeting facility designed for seminars and user meetings.

The heating, ventilation and air-conditioning systems are generally variable volume, constant temperature air supply systems providing standard temperature and humidity conditions. Computer rooms and laboratory clean rooms have separate specialized air-handling systems. The building's fire-protection system consists of smoke-detectors, sprinkler systems, and alarm-controlled zones electronically interlocked with Argonne's site-wide fire and security system. Utility systems are conventional, interconnecting with Argonne's existing site-wide utility system.

Conventional facilities for injection consist of the linear accelerator/klystron gallery building, the synchrotron injection building, the synchrotron extraction building, and the synchrotron ring tunnel.

(1) The linear accelerator/klystron gallery building is a long, narrow structure having an outer shell similar to a prefabricated metal building and joined on one side by a reinforced concrete and earth-shielded linear accelerator tunnel. The klystron gallery is an open bay with concrete floor slab and metal panel walls.

(2) The synchrotron injection building is similar to a prefabricated metal building. Appropriate shielding is provided by concrete blocks.

(3) The storage ring extraction building is similar in construction to the synchrotron injection building. Appropriate shielding is provided by concrete blocks. The building also has a five-ton overhead hoist.

(4) The synchrotron enclosure is an approximately circular reinforced concrete structure fully covered with earth berms which provide two feet of cover over the top and having sloped sides.

1. Title and location of project: 6-7 GeV Synchrotron Radiation Source
Argonne National Laboratory
Argonne, Illinois

2. Project No.: 89-R-402

8. Brief Physical Description of Project (continued)

The experimental hall/storage ring tunnel building is an annular shaped, metal clad building having an exterior radius of 628 feet, an inner radius of approximately 540 feet and is approximately 32 feet high. Steel columns and roof trusses provide a clear span approximately 88 feet wide for experimental beamline installation. A concrete "storage ring" tunnel approximately 1100-meters in circumference is located within the building near the inner wall. This tunnel has approximately 3-foot thick reinforced concrete walls and roof slab. The inside height is 9 feet and the width varies between about 9 and 21 feet in a sawtooth pattern.

The experimental hall building has separate air-handling units located between the roof trusses and is individually zoned to provide heat, air-conditioning, and humidity control. The storage ring tunnel is air-conditioned and exhausted to the extent necessary to remove equipment-generated heat only. All utilities are distributed to the building underground from the utility support building.

An emergency/service vehicle tunnel, 20 foot head clearance, is provided under the building for infield access. A pedestrian tunnel also connects the control room, the support wing, crosses under the experimental hall, and the extraction and injector buildings.

Two separate but identical service buildings, both with infield locations, house storage-ring magnet power supplies, radio frequency (rf) equipment, and electrical substations. The four laboratory/office modules are similar metal-framed one-story buildings with insulated metal exterior panels and concrete floor slab. These buildings are spaced at uniform intervals around the outside of the experimental hall/storage ring tunnel building and each contains offices, laboratories, conference areas, service support spaces, and truck air lock to facilitate delivery of technical components.

The utility support facility houses the mechanical and electrical equipment supporting the accelerator complex conventional facilities. It is a single-story, conventional metal-framed structure similar to a prefabricated metal building, with an 8-inch reinforced concrete floor slab. The facility has a 14-foot overhead truck access door and is located at a distance from the experimental hall to avoid transmitting equipment vibrations.

1. Title and location of project: 6-7 GeV Synchrotron Radiation Source
Argonne National Laboratory
Argonne, Illinois

2. Project No.: 89-R-402

8. Brief Physical Description of Project (continued)

Site Improvements: The completed project will occupy approximately 80 acres of relatively level, open land on the Argonne site. A standard perimeter road encircling the entire complex, will provide access to all quadrants and interconnect with Argonne's road system. The project center and the four office/laboratory modules will have paved parking facilities. Emergency and service access to the infield area of the experimental hall/storage ring will be via a 20-foot wide vehicle tunnel. A separate tunnel will accommodate personnel movement. A third tunnel will house all utility service lines entering the complex.

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

Over the past 20 years, synchrotron radiation emitted by circulating electron or positron beams has emerged as a very powerful and versatile source of vacuum ultraviolet light and x-rays and a very powerful tool for probing the structure of matter and for studying various physical processes. Several synchrotron radiation facilities with different designs and characteristics are now in regular operation in this country, the most recent additions being the 0.8 GeV and 2.5 GeV rings of the National Synchrotron Light Source at Brookhaven National Laboratory.

In October of 1983, an ad hoc committee was convened by the Department of Energy, Office of Basic Energy Sciences, with the charter to "solicit and evaluate ideas from synchrotron-radiation providers and users as to the future opportunities and technical needs for synchrotron-radiation based research." The committee had a membership of 17 scientists actively pursuing research using synchrotron radiation. The finding of the committee, briefly stated, is that the present research and development programs in materials science, physics, biology, and chemistry using synchrotron radiation can be greatly benefited by the availability of two additional facilities in the U.S. The one with the higher priority is a high-energy storage ring capable of providing fundamental undulator radiation in the x-ray region of the spectrum up to 20 keV, with an early 1990 target date for full operation. Such a storage ring requires an electron or positron beam of energy around 6-7 GeV. Both should be insertion device (undulator and wiggler) based machines designed to accommodate a large number of such insertion devices.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: 6-7 GeV Synchrotron Radiation Source
Argonne National Laboratory
Argonne, Illinois

2. Project No.: 89-R-402

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

The recommendation by the Committee was later studied and endorsed by the Major Materials Facilities Committee of the National Academy of Sciences and the top priority for the 6 GeV facility was strongly reaffirmed. Recently, this high priority national need was reaffirmed in the National Research Council (Brinkman) report - Physics through 1990's - and by the Stehle subcommittee of the DOE Energy Research Advisory Board.

During 1986 a National Task Group recommended that the synchrotron energy should be increased from the previously specified value of 6 GeV in order to provide wider tunability ranges of x-rays from undulator sources. Based on the report of that Task Group, 7 GeV has been chosen as the standard operating energy of the synchrotron. This document addresses the proposed construction of this new synchrotron radiation facility. This new facility would consist of a large storage ring containing as many as 34 insertion devices to give intense beams of hard x-rays. The injection and booster systems will be designed to inject positrons into the storage ring at the design energy of 7 GeV. Beam currents as high as 100 milliamperes and lifetimes of at least 10 hours are anticipated. Most importantly, the lowest possible beam emittance would be sought to give the highest brilliance x-ray source by a factor of 10,000 over any in existence. This facility would impact heavily on the field of physics, materials, chemistry, biology and medicine, and many technologies. Determination of bulk and surface structure will be performed with greater resolution and accuracy. Microprobe characterization will allow impurity detection in the parts per billion range. The high brilliance will make possible inelastic x-ray scattering which is an essentially unexplored field. Investigating time-dependent phenomena in biological membranes and in photosynthetic processes will be possible, as will observing the motion of atoms in protein systems. Angiography and analysis of tumor diseases will be advanced through non-invasive and very fast x-ray diagnostics without, or with the minimal use of, dyes or drugs. Topography will be extended to time-resolved studies of plastic deformation and fracture. All of these investigations are made possible by the photon energy, time-structure, intensity, and unusual brilliance of the radiation source. Other experiments important to national security needs can also be undertaken.

Research and development funding will be used to refine the lattice design of the storage ring, design and test new radio-frequency cavity systems, advance vacuum technology and surface cleaning techniques, and investigate beamline components that must handle greater x-ray intensities than at existing sources.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: 6-7 GeV Synchrotron Radiation Source
Argonne National Laboratory
Argonne, Illinois

2. Project No.: 89-R-402

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

Reliability, stability, and flexibility are emphasized in the accelerator, storage ring, and beamline designs. Specifically, the storage ring can accommodate all types of insertion devices with all tuning conditions desired by the users.

10. Details of Cost Estimate	Total Cost
a. Engineering, Design, and Inspection	$ 51,200
b. Construction Costs	
(1) Technical Components	191,285
(2) Conventional Facilities	130,820
c. Contingency	82,695
Total Project Cost	$456,000

11. Method of Performance

Customary accepted practice will be followed. Design of the conventional facilities will be performed under a CPFF architect/engineer contract awarded in accordance with established, DOE approved, procedures. Design of technical components will be performed by the Laboratory. To the extent feasible, construction and other procurements will be by means of fixed price contracts awarded on the basis of competitive bidding.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: 6-7 GeV Synchrotron Radiation Source
Argonne National Laboratory
Argonne, Illinois

2. Project No.: 89-R-402

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

	Prior Years	FY 89	FY 90	FY 91	FY 92	FY 93	FY 94	FY 95	FY 96	Total
a. Total Project Funding										
(1) Total facility costs										
(a) Construction line item	0	5,633	35,000	48,000	109,000	110,000	97,000	49,000	2,367	456,000
(b) Expense funded equipment	0	0	0	0	0	0	0	0	0	0
(c) Inventories	0	0	0	0	1,300	3,500	2,500	0	0	7,300
(2) Other project funding										
(a) R&D necessary to complete construction	13,835	6,322	10,441	16,352	18,500	17,707	12,500	7,500	*	103,157
(b) Other project related costs	0	0	0	0	6,000	12,000	17,000	32,000	*	67,000
(c) Conceptual design costs	3,465	0	0	0	0	0	0	0	0	3,465
Total Project Costs	17,300	11,955	45,441	64,352	134,800	143,207	129,000	88,500	2,367*	636,922

b. Other Related Annual Costs (estimated costs in thousands in FY 1988 dollars)

(1) Facility Operating Cost	$34,000
(2) Programmatic Research	10,600
(3) Capital Equipment Related to Programmatic Research	1,300
Total Related Annual Costs	$45,900

* Reflects completion of project with full operations at an estimated cost as reflected below in item b.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: 6-7 GeV Synchrotron Radiation Source
Argonne National Laboratory
Argonne, Illinois

2. Project No.: 89-R-402

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

a. Total project funding

(1) Total facility costs

(a) Construction line item - No narrative required

(b) Inventories

The spare parts inventory consists of specialized technical components which are not readily available "off the shelf" and have long lead times for procurement. These components include items such as rf accelerating cavities, klystrons, magnets, and beam diagnostic apparatus.

(2) Other project funding

(a) R&D necessary to complete construction.

These costs represent the R&D necessary to assure the best possible performance of the facility, to optimize conceptual engineering designs, and to develop the quality assurance plans for the testing of all hardware. The R&D plan includes: accelerator physics, including optimization of the current lattice and studies of alternative lattices, tracking with component errors and misalignments, nonlinear effects of the lattice and insertion devices, and vacuum chamber impedances; component prototyping and testing; designs for insertion devices and beamline components; detector development; and reexamination of the designs for the conventional facilities.

(b) Other project-related costs

These costs include startup, commissioning, and operating costs. Startup activity for the linac is scheduled to commence in FY 1992.

DEPARTMENT OF ENERGY
FY 1991 CONGRESSIONAL BUDGET REQUEST
CONSTRUCTION PROJECT DATA SHEETS
Energy Supply Research and Development - Plant and Capital Equipment
Basic Energy Sciences
(Tabular dollars in thousands. Narrative material in whole dollars.)

1. Title and location of project: 1-2 GeV Synchrotron Radiation Source
Lawrence Berkeley Laboratory
Berkeley, California

2. Project No.: 87-R-406

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

3a. Date physical construction starts: 2nd Qtr. FY 1988

4. Date construction ends: 4th Qtr. FY 1992

5. Previous cost estimate: $99,500
Date: January 1989

6. Current cost estimate: $99,500
Date: December 1989

7. Financial Schedule:

Fiscal Year	Authorizations	Appropriations	Obligations	Costs
1987	1,500	1,500	1,500	985
1988	18,000	18,000	18,000	10,317
1989	25,000	25,000	25,000	21,952
1990	25,636	25,636	25,636	30,050
1991	23,000	23,000	23,000 17.9 14.3	22,350
1992	6,364	6,364	6,364	13,846

8. Brief Physical Description of Project

The 1-2 GeV Synchrotron will be built within the Lawrence Berkeley Laboratory, which is located on University of California property adjacent to the Berkeley campus. The project will include the construction of new facilities, and alterations and additions to existing plant and site facilities, especially Building 6 (the circular building that now houses the 184-Inch Cyclotron). The 1-2 GeV Synchrotron is a special facility comprised of an electron storage ring and injection system, insertion devices (undulators and wigglers) for generating synchrotron radiation and photon beamlines. The facility consists of a 50-MeV injector, a full-energy booster synchrotron, an electron storage ring, which has 12 6-m-long straight sections for insertion

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8. Brief Physical Description of Project (continued)

devices (eleven could support insertion devices), an initial complement of insertion devices, and photon beamlines. Development of other straight sections and bending magnet ports are not included in the scope of this project. Their development in future years however, will provide flexibility to respond to new scientific directions and to take advantage of new materials, designs, and other technological advances. When fully developed, the facility will be able to provide up to 60 user stations.

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

The 1-2 GeV Synchrotron Facility will be a dedicated synchrotron radiation source that is optimized for generating vacuum ultraviolet and soft x-ray (XUV) light from periodic magnetic devices. Investigators from industry, universities, and national laboratories will have access to unique capabilities—high spectral brilliance and very short pulse length (nominally tens of picoseconds). Multi-period undulators in the storage ring will provide spatially and longitudinally coherent radiation that is broadly tunable across the XUV region of the spectrum.

The 1-2 GeV Synchrotron will permit new studies in both basic and applied science. In biology, for example, the high photon flux combined with the capability for wavelength tuning, will enhance imaging and scattering techniques. Picosecond pulses and the ability to match soft x-rays to the absorption features of major structural biological elements, such as carbon, nitrogen, and oxygen, will make it possible to undertake dynamical response studies of specimens in something very close to their natural state. The coherence properties of undulator radiation will extend the use of synchrotron radiation into the phase-sensitive world of x-ray interferometry and biological microholography.

In atomic and molecular physics, very high photon fluxes are needed for spectroscopic studies of free atoms and molecules in the gas phase; with radiation from undulators and wigglers an acceptable signal-to-noise ratio can be obtained for many experiments in the x-ray region. The facility will introduce new standards for spectral resolution, and will provide access to new studies of atomic structure and dynamics, quantum interference effects, and threshold phenomena.

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

In chemistry, the facility will open new areas of research on chemical reactivity. High spectral brilliance and picosecond time structure of the radiation will permit high-resolution dynamical studies of reaction kinetics, intramolecular transfer processes, excited state proton and electron transfer, and molecular photodissociation and photoionization.

In materials and surface science, the capabilities of the 1-2 GeV Synchrotron will permit new investigations of bulk materials as well as surfaces and interfaces. Time-resolved studies in catalysis will be possible with XUV radiation of extremely high brilliance and picosecond time structure. For instance, it will be possible to study the dynamics of surface contamination and interface formation and to verify microscopic models for catalysis, oxidation, corrosion, and interface growth.

Industrial utilization of XUV radiation will be stimulated by the availability of this radiation source, which can become a focal point for industrial-academic collaboration. One industrial application of radiation from the 1-2 GeV Synchrotron is improved mask fabrication for the microelectronics industry. By utilizing the full potential of synchrotron radiation for x-ray lithography, it will be possible to achieve finer feature sizes at less demanding aspect ratios, while competitive writing speeds are maintained.

In the area of national security, scientists at several national defense laboratories have expressed the need for access to a modern soft x-ray synchrotron radiation facility like the 1-2 GeV Synchrotron. They have emphasized dependable access to high-flux, high-brilliance facilities for program-related research.

These scientific opportunities are only a sample, indicating the potential for state-of-the-art synchrotron radiation research with the 1-2 GeV Synchrotron. The proposed facility will provide a much-needed addition to this country's oversubscribed synchrotron radiation sources, and will provide important new opportunities for student research and training in an area in which a lack of qualified personnel is already being felt. These scientific and educational opportunities have been well documented recently by national committees studying major research facilities needed to keep the United States scientifically competitive. These committees have consistently given the 1-2 GeV Synchrotron high priority. They include the DOE's Planning Study for Advanced National Synchrotron Radiation Facilities, the NRC's Major Materials Facilities Committee, and the DOE's ERAB Materials Facilities ad hoc Review Committee which reviewed the NRC report.

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

The 1-2 GeV Synchrotron will be available to general users as well as to participating research teams (PRT's). The Laboratory is determined to construct a user-friendly facility and has arrangements for users to play a significant role in determining the specification and design of the beamlines. Before commencing construction, LBL will conduct one more Users' Workshop to finalize operational parameters and organize beamline user teams. In addition, the 1-2 GeV Synchrotron has additional straight sections and ports on bending magnets that will be available for development by PRT's or for future facility enhancement by LBL to enable users to take advantage of new scientific opportunities or unforeseen technological developments. Realization of the full capabilities inherent in the 1-2 GeV Synchrotron configuration would result in support of up to 60 user stations.

10. Detail of Cost Estimate

	Item Cost	Total Cost
a. Engineering, design, inspection and administration (EDIA).....		$ 23,300
(1) Conventional construction at approximately 14%.....	$ 2,230	
(2) Special facilities at approximately 31%.....	13,720	
(3) Project management/administration.....	7,350	
b. Construction costs.....		58,560
(1) Conventional construction.....	14,880	
(2) Special facilities.....	43,680	
Subtotal.....		81,860
c. Contingencies at approximately 22% of (a & b).....		17,640
(1) Conventional facilities.....	2,770	
(2) Special facilities.....	14,870	
Total Project Cost.....		$ 99,500

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11. Methods of Performance

Conventional facilities engineering design will be performed under a negotiated Architect/Engineer subcontract. Inspection and some engineering will be done by LBL personnel. Construction and procurement will be accomplished by fixed-price subcontracts awarded on the basis of competitive bids.

The 1-2 GeV Synchrotron Radiation Source special facilities engineering design will be done by LBL personnel, as will major technical component construction and assembly. Technical components and standard equipment for the facility will be procured by fixed-price subcontracts awarded on the basis of competitive bids.

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

	FY 1987	FY 1988	FY 1989	FY 1990	FY 1991	FY 1992	Total
a. Total project costs							
1. Total facility construction costs.	$ 985	$10,317	$21,952	$30,050	$22,350	$13,846	$ 99,500
2. Other project costs							
(a) Storage Ring, Insertion Device, and Beamline R&D[a/]	1,500	2,000	1,873	1,000	---	---	6,373
(b) Startup.....	---	---	---	4,548	10,891	19,161	34,600
(c) Capital Equipment Related to R&D and Facility Startup...	500	500	1,000	1,500	1,000	1,000	5,500
Total other project costs..	2,000	2,500	2,873	7,048	11,891	20,161	46,473
Total project costs (Item 1 & 2).....	$ 2,985	$12,817	$24,825	$37,098	$34,241	$34,007	$145,973

a/ FY 1986 preconstruction R&D: storage ring R&D ($962).

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

b. Other related annual costs (estimated costs in thousands in 92 dollars)

1. Facility operating costs	$21,300
2. Programmatic research	1,400
3. Capital Equipment Related to programmatic research	1 900
Total related annual costs	$24,600

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

a. Total project funding

1. Site preparation and building construction for the facility is scheduled for FY 1988-1991, in order that the building be ready for installation of the injector and the storage ring. Fabrication of the beamlines and insertion devices is scheduled for FY 1990-1992.

2. Other project funding
Storage ring R&D activities include (a) accelerator physics studies of lattice design, stabilization of high-current beams; (b) development of ultra-high vacuum technology; (c) beam control and instrumentation system development; (d) radio-frequency accelerating system development; and (e) magnet system prototyping. Insertion devices and beamline R&D activities include high-fidelity magnetic structures, in-vacuum undulators, and advanced beamline components suitable for high-brilliance photon beams.

Startup funding requests are for operations staff training, startup of the injector, and startup of the storage ring.

Capital Equipment related to R&D includes equipment needed for the development of the above items.

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

b. Other related funding requirements

Facility operating costs represent estimates for the personnel, supplies, utilities and maintenance funding that will be needed to effectively operate a user-friendly facility. These costs, along with supporting capital equipment estimates, are based on Laboratory experience in operating national accelerator facilities and on a survey of operating experience of existing synchrotron radiation sources. The annual costs for programmatic research will support activities associated with maintaining and developing the scientific capabilities of the facility staff in order to assure that the support provided to facility users is of the highest quality and that the continued development of the facility reflects the needs of the scientific and technological community. Because the 1-2 GeV Synchrotron Radiation Source will be primarily a national user facility, research funding to support facility users will be available through related activities of this and of other agencies and researchers affiliated with universities, national laboratories, and industry.

Due to the rapid advance in the technology in synchrotron radiation, and the need for precision in the machine, the Department continues to evaluate ways to maximize facility performance. As advances are made, and to the extent that we can gain by incorporating improvements to the facility, we will continue to work with the Congress to ensure that the nation gets an optimum research facility at an affordable price.