Department of Energy
FY 1984 CONGRESSIONAL BUDGET REQUEST

PROGRAM OVERVIEW

Supporting Research and Technical Analysis

The need to develop new and improved energy sources and to use energy more efficiently continues to be extremely important to the general welfare of the Nation. The role of basic (or supporting) energy research and technical analysis is to expand the scientific and engineering knowledge base on which the Nation's future energy options depend and to provide independent, objective analyses and assessments of research and technical needs relating to energy. Funding of basic research is an investment in the future. Through this investment, the applied technology efforts of industry and government will have a broader foundation of knowledge from which to discover new concepts, materials, processes and techniques important for energy production, conservation and utilization. Failure to strengthen our fundamental knowledge base of energy-related phenomena could result in limitations on productivity growth, erosion of the country's competitive position with foreign nations, additional pressure on the United States balance of trade and continuation of inflationary trends.

The following seven programs comprise the Office of Energy Research's portion of the Supporting Research and Technical Analysis category of the agency's budget: (1) Basic Energy Sciences (BES); (2) Energy Research Analysis (ERA); (3) Advisory and Oversight Program Direction; (4) University Research Support (URS); (5) University Research Instrumentation (URI); (6) Multiprogram General Purpose Facilities (MGPF); and (7) Policy and Management. All seven of these programs are organizationally in the Office of Energy Research.

The Basic Energy Sciences program is responsible for the long range, basic research of the agency to provide the fundamental scientific and engineering base on which the Nation's future energy options depend. The major product of the BES program is increased knowledge. This knowledge is developed by sponsoring research in the traditional disciplines: the physical and biological sciences, engineering and mathematics. The product of research in these disciplines then becomes a part of the body of data on which applied technologies rest. In addition to this focus on disciplinary research, there is also an emphasis on innovative applications of new knowledge to energy problems, and on the early application and, if possible, direct commercialization of the results.

Some examples of BES research efforts impacting technology areas of major interest are: new research results on stress corrosion cracking that already are being used to evaluate intergranular corrosion of the nickel based alloys that are being used in nuclear steam generators; several projects related to nuclear waste isolation which have provided new insights into important aspects of plutonium migration: these include effects of chemically active leachants generated in the focal aqueous medium by the high radiation field itself, immobilization effects of soils rich in organic humic materials, and the radiation stability of a simulated mineral planned to be a component in a long term storage host material for nuclear waste.

A solar related research result has been the experimental observance of a phenomenon in light-excited semiconductors which could lead to a doubling in the efficiency of photoelectrochemical solar devices. Related to transportation, conservation or electric generation technologies, the scientific feasibility was the demonstration with BES support of producing batteries, both storage and primary, with electrodes made of lightweight polyacetylene sheets. The successful demonstration of this concept can pave the way for a whole new technology and considerably improve the outlook for electrically powered vehicles.

The Energy Research Analysis (ERA) program provides the capability for independent, rigorous assessment of the base of research that underlies a variety of energy technologies. Assessments are consolidated under one organization, the Office of Energy Research, in fulfillment of legislated responsibility for the Director to advise the Secretary on the agency's research and development programs.

The University Research Support (URS) program consists of two major subprograms and a set of program activities focused on the following three primary objectives: To strengthen university capability to do energy research; to strengthen the quality and increase the number of students interested in pursuing energy-related professional careers; and to enhance technology transfer activities through cooperative research efforts between universities, the agency's national laboratories and private industry. The first subprogram, the University/National Laboratory Cooperative Research Program, is directed at strengthening the capabilities of both universities and national laboratories as major energy research performers in the conduct of long range energy research. Many of the activities supported within this subprogram involve joint efforts between university and laboratory-based researchers. The second subprogram, the Energy Manpower Development Program, includes efforts to increase the number of students pursuing energy-related engineering and science careers. This subprogram also includes the Department's statutory responsibility for assessing the supply and demand of manpower for both current and projected energy R&D programs.

The University Research Instrumentation (URI) program supports the purchase by the major research universities of state-of-the-art, scientific instrumentation used in energy-related research areas such as combustion, biological energy conversion, catalysis, radioactive waste management and engineering research.

The goal of the Multiprogram General Purpose Facilities (MGPF) program is to provide for the rehabilitation and replacement of general support facilities required to continue the operation of the agency's multiprogram laboratories. MGPF include facilities which are suited to many different users and programs; these are roads, railroads, site utilities, and support buildings such as laboratories, office buildings, shops, warehouses, etc. They are restricted to facilities where no one program uses more than approximately 60 percent of the facility.

The replacement cost of the existing general purpose facilities at the multiprogram laboratories is over $8,000,000,000. The MGPF program is required to maintain this investment and to ensure its viability. The program will be required as long as the multiprogram laboratory facilities are utilized to perform research and development functions for the agency. The program is an appropriate Federal role reflecting the responsible management of the Government's real property. The program is based on the premise that through continuous usage and aging, facilities deteriorate over time to a point where they are no longer useful to perform their intended functions and must be rehabilitated or replaced.

Advisory and Oversight Program Direction provides funds for the personnel resources required by the Director of Energy Research to carry out his responsibilities specifically assigned by legislation (P.L. 95-91) as well as those mandated by the Secretary in areas beyond the scope of the Energy Research and development program in order to advise the Secretary with respect to the well-being and management of the multiprogram laboratories; supervising or supporting research activities carried out by any of the Assistant Secretaries; and providing for program management of the Energy Research Analysis, University Research Support, and Multiprogram General Purpose Facilities programs. The program provides funds only for the salaries and related personnel expenses for the personnel who carry out the studies, analyses, monitoring and coordination activities required to support the Director. It does not include any funds for outside contracts.

The Office of Energy Research Policy and Management program provides for the salaries and related expenses associated with staff in the immediate office of the Director, Office of Energy Research, and in the Office of Management.

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LEAD TABLE
Basic Energy Sciences
Energy Supply Research and Development - Operating Expenses
Energy Supply Research and Development - Plant and Capital Equipment
(Tabular dollars in thousands. Narrative material in whole dollars)

	FY 1982 Appropriation	FY 1983 Appropriation	FY 1984 Base	FY 1984 Request
Basic Energy Sciences (BES)				
Materials Sciences				
Operating Expenses........	$ 95,506	$108,700	$108,700	$125,110
Capital Equipment.........	7,960	8,510	8,510	12,780
Construction..............	600	3,000	3,000	29,340
Subtotal................	104,066	120,210	120,210	167,230
Chemical Sciences				
Operating Expenses........	63,187	70,000	70,000	75,500
Capital Equipment.........	4,940	5,510	5,510	6,520
Construction..............	0	400	400	450
Subtotal................	68,127	75,910	75,910	82,470
Nuclear Sciences				
Operating Expenses........	22,407[a/]	30,644[c/]	30,644	37,900
Capital Equipment.........	860[b/]	1,556[c/]	1,556	2,150
Construction..............	0	0	0	270
Subtotal................	23,267	32,200	32,200	40,320
Engineering, Mathematical and Geosciences				
Operating Expenses........	24,864	31,050	31,050	33,670
Capital Equipment.........	1,900	1,920	1,920	2,120
Subtotal................	26,764	32,970	32,970	35,790
Advanced Energy Projects				
Operating Expenses........	7,310	8,300	8,300	9,100
Capital Equipment.........	320	290	290	310
Subtotal................	7,630	8,590	8,590	9,410
Biological Energy Research				
Operating Expenses........	8,419	9,500	9,500	10,580
Capital Equipment.........	410	370	370	400
Subtotal................	8,829	9,870	9,870	10,980
Program Direction				
Operating Expenses........	2,500	3,100	3,810	3,970
Subtotal................	2,500	3,100	3,810	3,970
Total				
Operating Expenses..........	224,193	261,294	262,004	295,830
Capital Equipment...........	16,390	18,156	18,156	24,280
Construction................	600	3,400	3,400	30,060
Basic Energy Sciences.........	$241,183	$282,850	$283,560	$350,170
Staffing FTP/Total FTE's......	52/56	54/60	54/60	58/62

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

a/ Operating funds of $12,257,000 previously budgeted in this subprogram for low energy nuclear physics research are now being budgeted in the Nuclear Physics program.

b/ Capital equipment funds of $510,000 previously budgeted in this subprogram for low energy nuclear physics research are now being budgeted in the Nuclear Physics program.

c/ Reflects the transfer of the Stanford Synchrotron Radiation Laboratory from the National Science Foundation to the Nuclear Science subprogram. Funds associated with this facility are $6,800,000 in FY 1983.

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SUMMARY OF CHANGES
Basic Energy Sciences
(dollars in thousands)

FY 1983 Appropriation..	$282,850
o Sustain program elements at the comparable FY 1983 level..............	+ 15,370
o Provide for the modest increases in each subprogram in the most promising new research areas; provide increases required for facility operations, GPP and AIP; and enhance the research capability of the program by equipment replacements and additions (e.g., for the ORNL calutrons)..	+ 10,780
o Provide for an advanced materials research initiative which will include two major construction projects and directly related research and equipment. The new construction projects are a National Center for Advanced Materials at LBL and an expansion of capability at the National Synchrotron Light Source at BNL............................	+ 38,000
o Provide for the Heavy Ion Fusion Research program which is a new program under the aegis of Basic Energy Sciences having previously been funded by Defense Programs....................................	+ 5,000
o Provide for increased funding for staff salary and benefits and the addition of 2 full-time equivalents above the revised FY 1983 level...	+ 870
o Construction funds for the Improvements to the Weapons Neutron Research Facility were provided in FY 1983 and will not be required in FY 1984..	- 2,700
FY 1984 budget..	$350,170

Overview

The Administration has taken the strong position that the achievement of the Nation's economic goals will depend in large part on knowledge produced by a strong, broad national science capability. Cost analyses by leading U.S. economists have shown that half the growth in the productivity of the United States is due to the advance of scientific knowledge. In its determination of the appropriate Federal roles in the support of RD&D, the Administration has identified the support of long range basic research as the particular responsibility of government and further, that "mission agencies should support the foundation of basic science, as well as mission-oriented applied research, in appropriate disciplines." Further, both the Congress and the Administration have focused attention on the particular importance to U.S. economic well being of advancing knowledge and capabilities in the material sciences.

Improvements in existing technology and the development of new technologies invariably come from the application of new scientific knowledge. External blue ribbon review groups have repeatedly recommended that Government agencies increase funding of basic research and have called for the Office of Basic Energy Sciences (BES) to be given a larger role in developing the needed technology base for the different energy supply and conservation options. BES has endeavored to respond to these recommendations. The major product of the BES program is the knowledge relevant to energy exploration, production, conversion and use; that product becomes a part of the body of information on which the applied technologies rest. While the pursuit of research by BES to broaden the technology base needed for identified energy technology options is extremely important, perhaps even more important is the need for basic research unconstrained by preconceived notions of what technologies will be important several decades from now, so that new, currently unidentified options may emerge.

In support of basic research activities, BES has recently completed construction of three important user facilities: the National Synchrotron Light Source (NSLS), the Intense Pulsed Neutron Source (IPNS), and the 1.5 MeV electron microscope at LBL. FY 1983 will be the first full year of operation of these newer facilities. Also in FY 1983, the Atomic Resolution Microscope, delivered in FY 1982, will begin operation and BES will undertake the responsibility for the operation of the Stanford Synchrotron Radiation Laboratory (SSRL), our second major research facility for synchrotron radiation. In addition, FY 1982 has been the first full year of operation of the Combustion Research Facility. A commitment to continuity of current productive activities, real growth in specified areas, and a new Advanced Materials Research initiative is required to implement stated national policy in the FY 1984 budget.

Examples of how basic research discoveries can enhance the energy alternatives available to us and improve our understanding of energy-related phenomena are discussed below in each of the subprogram areas.

In the Materials Sciences subprogram the thrust is towards understanding basic phenomena related to the structure and properties of materials. This past year saw the first experimental observation of a new phase in a rare earth-rhodium boron alloy, a phase in which, unexpectedly, the properties of ferromagnetism, oscillatory magnetism and superconductivity coexist. This subprogram also provided new research results on stress corrosion cracking, results that are being used to evaluate intergranular corrosion of the nickel base alloys being used in nuclear plant steam generators, and it developed new information explaining radiation instability of a component planned for use in a long term storage "host" for nuclear waste.

Under the Chemical Sciences subprogram a considerable improvement was attained in the precision of measurement of the ratio of the sulfur-32 isotope to sulfur-34 in air. This improvement is critical to establishing a reliable measurement technique that could be used to distinguish among possible sources of sulfur present in acid rain. A second accomplishment was the experimental observance of a phenomenon in light-excited semiconductors which had been theoretically predicted and, if harnessable, could lead to a doubling in the efficiency of photoelectrochemical solar devices.

Several accomplishments under the Nuclear Science subprogram related to nuclear waste isolation include evidence that plutonium immobilized in glass being considered for ultimate disposal can be affected by chemically active leachants generated in the aqueous medium by the high radiation field itself. This new insight on the effect of radiation on the glass host/aqueous leachant system can affect key decisions in this area. It was also found in studies of the binding of actinides to naturally occurring organic materials that the migration of plutonium through soils rich in these materials would be very slow. Certain forms of the actinide nuclear wastes become strongly bound to organic humic materials, and thus, are essentially inert to further chemical reactions.

Under the Engineering, Mathematical and Geosciences subprogram, an applied math effort involving "automated reasoning" provided an elegant solution to the problem of showing that single component failures could not inhibit nuclear reactor shutdown; this solution was needed to verify a condition required for nuclear plant licensing. A geosciences effort showed that Columbia River basalts have chemical properties that can provide a safety factor for the immobilization of long lived actinides such as neptunium.

A recent accomplishment under Advanced Energy Projects has been the demonstration of the scientific feasibility of producing batteries, both storage and primary, with electrodes made of light polyacetylene sheets (rather than lead). The successful demonstration of this concept can pave the way for a whole new technology and considerably improve the outlook for electrically powered vehicles.

The Biological Energy Research subprogram has made progress in determining how plant systems "sense" temperature. While there is much to learn about this process, it is an extremely important area of endeavor; plants initiate adaptive processes in response to the environment. Control of such responses could ultimately lead to artificially adapting plants for specific environments, e.g., for producing biomass in geographic locations areas where it is not now economically feasible.

BES considers the merits of research in relation to the diverse needs for energy development and selects those topics that, when taken as a whole, comprise an optimum, balanced program of mission-oriented basic research. To carry out this program, BES plans, supports and administers energy related research in the physical and biological sciences, engineering and applied mathematics. New scientific information in these areas addresses the Administration's goals by providing the fundamental scientific and engineering base on which the Nation's future energy options depend. The strategy is to:

- o Provide critical knowledge and data and develop trained scientific talent through support of highly competent scientists in DOE mission areas;
- o Provide for, and support operation of unique, specialized research facilities;
- o Maintain liaison with other energy programs, federal agencies and the scientific, academic and industrial communities;
- o Seek the scientific and industrial communities' assistance for the identification of needs and opportunities for research in areas likely to be relevant to future energy options; and
- o Promote early applications of the results of basic research.

Research carried out by the Basic Energy Sciences program provides knowledge that cuts across the missions of all of the energy technology development programs.

At the heart of this strategy is the need for program continuity concurrent with reasonable opportunities for growth in newer, emerging areas of science. To continue its effectiveness, the Basic Energy Sciences program must: 1) maintain a strong core program -- this involves equipping, supporting and encouraging the scientists involved in our current program activities, 2) have growth opportunity to exploit new, emerging areas that have been identified as having great potential importance to energy, and 3) continue to support existing, unique facilities important to research in the U.S. while at the same time providing for needed new facilities and for their operation.

A prime example of the importance of an opportunity for growth is the relatively new field of synchrotron radiation research. A National Academy of Science (NAS) study conducted in 1976 outlined opportunities for synchrotron radiation research and is the basis for current U.S. efforts. The National Synchrotron Light Source construction at BNL was supported by the NAS report findings; many of the areas outlined in the early report are now under intense investigation. The Stanford Synchrotron Radiation Laboratory at Stanford University (SLAC) also was expanded in response to the opportunities identified in 1976. Only because the U.S. Government had the foresight to provide the additional support needed to construct, and now to operate, these facilities has the U.S. established a lead role in this area. Through these and similar unique facilities, industrial and academic scientist users, are provided the capability for research not otherwise available to them. New opportunities and areas of research are emerging that were not conceived of six years ago when the NAS study was carried out. In FY 1984 a new Advanced Materials Research initiative is proposed which will include a new synchrotron radiation source and expansion of capability at NSLS to further expand and exploit opportunities in the field of materials sciences and other fields. In addition, a new Heavy Ion Fusion Research program will be initiated to advance the accelerator technology for this very promising inertial confinement fusion approach.

At the FY 1984 request level, BES is seeking $350,170,000: 1) $295,830,000 for operating expenses, 2) $24,280,000 for capital equipment, and 3) $30,060,000 for construction. Of the operating and equipment increase, $15,370,000 provides for a cost of living allowance. The remaining increase for operating and equipment will: 1) include replacement equipment for the ORNL calutrons, purchase of initial components for an advanced analytical electron microscope, ion-implantation equipment, and special equipment for the NSLS and several other facilities; 2) provide for funding needed above the allowed cost of living for the operation of new user facilities and for new fuel element fabrication for HFBR and HFIR; 3) provide for modest increases in each of the subprograms in some of the most promising new research areas; 4) permit an Advanced Materials Research initiative to be started that is responsive to Congressional interest in materials research and is in consonance with the President's material policy statement; 5) initiate a program in Heavy Ion Fusion Research; and 6) provide for increased personnel costs and for an increase equivalent to two full-time staff years for program direction.

The requested construction funds will permit initiation of construction projects required under the proposed Advanced Materials Research initiative ($28,400,000): 1) a National Center for Advanced Materials ($25,900,000) and 2) the expansion of capability at the recently dedicated National Synchrotron Light Source ($2,500,000); and also permits implementation of several much needed Accelerator and Reactor Improvement Projects and GPP projects ($1,660,000).

Further description of the FY 1984 budget request is given below in the seven major subprograms which make up Basic Energy Sciences. These are 1) Materials Sciences; 2) Chemical Sciences; 3) Nuclear Sciences; 4) Engineering, Mathematical and Geosciences; 5) Advanced Energy Projects; 6) Biological Energy Research; and 7) Program Direction.

Materials Sciences	FY 1982	FY 1983	FY 1984 Request
Operating Expenses	$ 95,506	$108,700	$125,110
Capital Equipment	7,960	8,510	12,780
Construction	600	3,000	29,340
Subtotal	$104,066	$120,210	$167,230

The goal of the Materials Sciences subprogram is to increase our understanding of phenomena and properties important to materials behavior which will contribute to meeting the needs of present and future energy technologies. It is well known that materials problems and limitations often restrict the performance of current energy systems and the development of future systems. A few examples of such problems and limitations include: low conversion efficiency in photovoltaic materials, radiation damage in fusion systems, thermal and mechanical stability of materials for heat engines, and corrosion and erosion of critical components in coal conversion plants. The Energy Research Advisory Board has placed the highest relative program ranking on this area of research in a recent review of major energy activities Science and Technology base programs.

This year, in response to Congressional interest in materials research and in consonance with the President's materials policy statement, an Advanced Materials Research initiative is being proposed. This new initiative is described separately and builds upon the base of knowledge established by the Materials Sciences program and other such programs in the Government. It will complement ongoing core program activities, emphasize high risk, high pay-off research with potential for technology transfer, and assure United States leadership in the field of materials science.

The FY 1984 request includes funds for the Core Program, $117,410,000 for operating, $10,880,000 for capital equipment and $940,000 for construction and for a new initiative on Advanced Materials Research, $7,700,000 for operating, $1,900,000 for capital equipment, and $28,400,000 for construction.

The opportunities for significant advances in materials research are ripe for exploitation. The high flux sources of x-rays such as the recently dedicated National Synchrotron Light Source, permits studies of materials surfaces at unprecedented levels of detail and also under dynamic conditions. New microscopy facilities have begun operation. The recently installed LBL microscope, the highest voltage United States instrument, and the Atomic Resolution Microscope which will begin operation in FY 1983, will allow materials to be examined at resolutions important in the determination of materials properties. New pulsed neutron sources are being developed here and abroad which will be used to study the fundamental structure of matter in energy regimes never heretofore observed. These new instruments coupled with steady advances in theory and the ability to prepare new well characterized combinations of elements and structures (such as the layered ultrathin coherent structures and ion-implanted alloys) are ushering in a real opportunity for advancements in the entire materials technology field. The research area of surface modification is one where new developments are taking place which hold promise not only for improving properties, but also for reducing the quantity of critical/strategic materials needed. Ion implantation techniques coupled with laser annealing are being developed to a point where almost any combination of elements can be inserted into the surface of a material to improve its electrical, corrosion resistance, or mechanical properties.

Some of the needs to which the Materials Sciences research ultimately contributes include:

- o Developing new or substitute materials
- o Tailoring materials to satisfy defined requirements
- o Predicting materials problems and service life

- o Improving the ability to successfully attack unforeseen materials problems in advanced energy systems, and

- o Improving the theoretical and experimental capability to analyze the fundamental structure of materials

To provide the new knowledge and information to meet these needs, Materials Sciences, comprised of the subfields of metallurgy, ceramics, solid state physics and materials chemistry, places emphasis on selected generic areas of fundamental importance and on areas where problems are known to exist or are anticipated. Some research is directed at a single energy technology (e.g., photovoltaic materials for solar energy conversion), some research would have applicability to many technologies simultaneously (e.g., embrittlement of structural materials due to the presence of hydrogen), and still other research has more fundamental implications underpinning all materials research (e.g., mechanisms of atomic transport of solids). The research is conducted among a variety of institutions - national laboratories, universities, and to a lesser extent, industry utilizing the talents of metallurgists, ceramicists, solid state physicists, and materials chemists.

This subprogram supports both directly and indirectly the activities of the Committee on Materials (COMAT) in developing a national position on critical materials. The ability to provide such support stems directly from the experience and continuity within the Materials Sciences subprogram. The fundamental understanding of materials obtained in this subprogram has led to new approaches to alloy design for critical materials substitution and conservation.

The subprogram utilizes workshops and reports of its Council on Materials Science (a non-Governmental body with representatives from academia, industry, and agency laboratories) to help focus on critical issues. Panel meetings on Radiation Effects and on the Role of Computation in Condensed Matter Research were conducted in 1981. During 1982, two panel meetings were held - Materials Research at High Pressure, and Materials Aspects of Nuclear Waste Isolation. The reports resulting from these workshops and panels are distributed widely, including publication in the open literature. Interactions and information transfer with the agency's applied materials research takes place through a number of mechanisms including a formalized Research Assistance Task Force. Recent examples include meetings on materials problems in molten carbonate fuel cells and constitutive equations of mechanical behavior in geological repository materials. Through these latter meetings the basic researchers learn of the problems in the applied programs and the technology oriented programs are exposed to scientists with a fundamental understanding of matter.

In addition to maintaining an appropriate mix among long-term science, multi-technology and single energy technology oriented research, a balance must be retained between forefront large facility-related research and small individual projects. Certain types of research simply cannot be carried out without large facilities (e.g., neutron sources with significant fluxes of neutrons cannot be made in "small" sizes). Also newer instruments with significant improvements in capability (e.g., synchrotron radiation sources) are very expensive to build and operate. The Materials Sciences subprogram utilizes several major facilities in the pursuit of its research goals, including the National Synchrotron Light Source (NSLS) BNL, High Flux Beam Reactor (HFBR) BNL, High Flux Isotope Reactor (HFIR) ORNL, Intense Pulsed Neutron Source (IPNS) ANL, Ion Implantation Facility ORNL, and High Voltage Electron Microscopes (HVEM) at ORNL, ANL and LBL. Operation of these facilities requires about 18 percent of the operating budget of the Materials Sciences subprogram, not including the unique research associated with them. These facilities also are available to qualified users outside the national laboratory complex.

Current emphases and trends in the core program indicate utilization of the major user facilities will increase. The university portion of the program will be maintained at about 20 percent. When including Ames Laboratory (Iowa State University) and Lawrence Berkeley Laboratory (University of California) the support going to universities is approximately 38 percent. Research will be strengthened in the areas of nuclear waste isolation, surface modification, interfaces, grain boundaries, condensed matter theory, amorphous materials, structural ceramics, critical materials substitution and non-destructive evaluation among others.

The Materials Sciences subprogram is the basic materials program in the agency underpinning all the energy technologies and over $400 million of applied materials R&D required by energy activities technology programs. That applied materials development commands a large fraction of the total materials R&D effort is testimony to the crucial role materials play in the development of energy systems. Coordination of the agency's materials programs takes place primarily through the Energy Materials Coordinating Committee. Within the Federal government, the subprogram is coordinated in part through the interagency Committee on Materials (COMAT). At the Federal program level, Materials Sciences represents about one-third of the Federal Government support for basic materials research.

Materials Sciences is recognized throughout the research community for its excellence. Past technical accomplishments have moved into the technological or commercial sector (e.g., radiation resistant alloys, glassy metals, ion implantation techniques for surface modification, and superconducting wire), and it is expected that through the proven methods of technology/information transfer and effective management this year's accomplishments will likewise find use either for building our fundamental base of materials understanding or in some technological application in the future. It should be noted that industrial interactions with this subprogram are encouraged and indeed have been successful. Significant progress was made during the past year in many areas of the subprogram. Some examples of recent accomplishments include:

- A new phase of matter was discovered at low temperature where ferromagnetism, oscillatory magnetism and superconductivity coexist. Present theory predicts this to be impossible.

- The radiation induced resistivity changes in copper were found to be significantly high; as a result, magnet designers are beginning to factor this data into the considerations of fusion reactor lifetimes.

- New research results on stress corrosion cracking (SCC) of alloys in aqueous solutions have shown the importance of borate ions (a threshold ratio of borate to thiosulfate ion) in inhibiting SCC. These results are now being used at the Three-Mile-Island steam generator to evaluate intergranular SCC of its nickel-base alloys.

- Interesting new results on cesium implanted into nickel have shown that hydrogen is strongly bound to cesium. This suggests the possibility of using cesium to prevent hydrogen embrittlement in critical components.

- Friction was found to be greatly reduced at iron surfaces as a result of ion implanted titanium and carbon. An amorphous ternary layer was observed to form from the process.

- An important new high temperature solar energy absorbing film was discovered. The material, zirconium diboride, was prepared by chemical vapor deposition and shows excellent long-term stability in air at 600°C.

- A new process for silver recovery was discovered that produces greater than 99.99 percent silver removal from photographic spent fixer solutions. Not only is it important for silver recovery, but it also meets stringent environmental standards for pollution levels of silver and cyanide in streams.

- Recent bulk measurements of radiation instability (swelling) of zirconolite under accelerated testing conditions were found to show significant instability in contrast to previous x-ray measurements. These new results may affect the use of zirconolite on a proposed synthetic ceramic nuclear waste host called SYNROC.

- o Using radiation from a synchrotron radiation source, the surface structure and temperature distribution for silicon after laser heating were determined for the first time.

The request for the Materials Sciences core program will provide for needed continuity and permit a reasonable level of utilization of major facilities, strengthening of important topical areas and a start in some new thrust areas recommended by workshops and panels of the Council on Materials Science. Of the $8,710,000 increase in operating funds in the core program over FY 1983, the most significant amount is for inflation ($5,980,000) and $2,730,000 is to meet program commitments involving operation and research at newer major facilities. The operational funding for NSLS will increase, which together with the Chemical Sciences funding for NSLS will allow NSLS to run 13 shifts per week, a modest increase over FY 1983.

Additional funding will be allocated to the other major facilities for operational costs, for example to the LBL Center for Electron Microscopy in order to permit close-to-optimum outside use. FY 1984 will be the first full year of operation for the Center. The 1.5 MeV High Voltage Electron Microscope has begun operation and the Atomic Resolution Microscope should begin operation during FY 1983. These two microscopes will provide extremely powerful complementary instruments, the Nation's best, to examine the structure of materials. Strengthening of research on materials synthesis, pulsed neutron research at WNR/PSR-LANL, nuclear waste isolation and surface modification including ion implantation will be supported with funds in this request. Some major new thrusts which will be undertaken at a modest level include: alloy design for critical material substitution/conservation; computer simulation and theory; polymer research especially on polymers with high conductivity and corrosion resistance; high resolution electron microscopy, especially work associated with the new Atomic Resolution Microscope; support for new participating research teams to utilize the NSLS; and theory, modeling, and experimentation related to the quantitative predictive behavior of materials.

The increase in equipment funds will allow a start on the purchase of an advanced analytical electron microscope which will cost a total of about $1 million. The request will also allow purchase of ion implantation equipment to expand the user capability at ORNL. GPP ($300,000) funds are requested for Ames and Notre Dame; and Accelerator and Reactor Improvement funds are requested for NSLS ($500,000) and HFBR ($140,000) in the core program. Supporting information is provided in the construction project data sheet.

In addition to the Materials Sciences core program, funds for an Advanced Materials Research initiative are requested. This is an initiative carefully designed to satisfy a national need in materials science research and in response to Congressional interest and Administration policy. Funding for the initial year, FY 1984, includes operating expenses ($7,700,000), capital equipment ($1,900,000) and construction ($28,400,000).

United States economic health and national security requires the maintenance of a commanding lead in high technology and the reduction of vulnerability to critical and strategic imported materials.

In response to this challenge, an Advanced Materials Research initiative is proposed. The Advanced Materials Research initiative will be organized to provide maximum benefit to U.S. industry. Industry will participate in the design and use of the facilities to assure that the research addresses America's high-technology needs. For example, at the National Center for Advanced Materials (NCAM), an advisory board composed of scientific leaders from industry, universities, and Federal laboratories will advise the LBL director on NCAM scientific program directions. The NCAM affiliates, consisting of major research teams from industry and universities, will participate in the design, construction, and use of the Advanced Light Source (ALS), a new proposed synchrotron radiation source, and beam lines. An ALS program advisory committee will review research proposals for the use of ALS beam lines by all qualified experimenters. An NCAM Industrial Fellows program will be established to provide joint LBL-industrial support for participation at NCAM of outstanding industrial scientists in basic research studies of mutual interest to LBL and the scientists' parent companies.

This new initiative will include funds for: A) two construction projects (a National Center for Advanced Materials-$25,900,000 and the expansion of capability at the recently dedicated National Synchrotron Light Source-$2,500,000); B) research associated with construction $5,100,000; and C) a forefront research program $4,500,000.

	FY 1984 Request
A. Construction..	$ 28,400

National Center for Advanced Materials

The National Center for Advanced Materials project provides for the construction of four new facilities: 1) an Advanced Light Source (ALS); 2) a Surface Science and Catalysis Laboratory (SSCL); 3) an Advanced Materials Synthesis Laboratory (AMSL); and 4) an Advanced Device Concepts Laboratory (ADCL). As part of this project funds are provided for improvements at the Stanford Synchrotron Radiation Laboratory (SSRL). Each of these is described further below:

Advanced Light Source (ALS)

The ALS, which will deliver photon fluxes some 10,000 times those of present synchrotron light sources (in its optimum energy range) in pulses of about $3x10^{-11}$ sec duration, will be a major national asset. The ALS is designed to optimize photon fluxes in the energy range from 0.1 to 5000eV. It will thus complement the high photon energy facility at SSRL for the western part of the United States. Its unique time structure will permit the study of atomic motion and reaction kinetics on the 10^{-11} sec scale. Projections of usage indicate that the capacity of present synchotron light sources will be saturated by about 1984 and this project will meet those needs.

Surface Science and Catalysis Laboratory (SSCL)

The SSCL will further the fundamental understanding of surfaces of materials with a view toward applications and catalyzed processes on solid surfaces.

Advanced Materials Synthesis Laboratory (AMSL)

The AMSL will create a forefront facility for the synthesis and characterization of materials of novel or optimized physical or chemical properties.

Both SSCL and AMSL will build up upon the very strong programs in materials science and in surface science and catalysis already in existence at LBL.

Advanced Device Concepts Laboratory (ADCL)

ADCL will provide a focus for development of innovative devices and use of advanced materials to create among other things whole new types of advanced engines with new materials. Innovative device concepts for more sophisticated characterization of materials properties or behavior will be created.

Stanford Synchrotron Radiation Laboratory (SSRL)

A complementary program at the Stanford Synchrotron Radiation Laboratory (SSRL) will provide for construction of equipment to increase brightness of synchrotron radiation beams from the existing 4 GeV PEP storage ring, and for equipment to improve injection of electrons into SPEAR and to eliminate adverse effects of vibration of SPEAR performance. These improvements and new facility capabilities will complement the ALS in the hard x-ray region, thereby, providing unparalleled photon brightness over this extended portion of the electromagnetic spectrum. The new beam line at PEP will require an access tunnel and an underground bore for the beam line.

National Synchrotron Light Source (NSLS)

The second construction project will expand the capabilities at NSLS by allowing new beam lines to be built and by enlarging the existing building for the purpose of permitting additional experiments to be conducted. The proposed building expansion will be a structure extending to the northern perimeter of the existing building and add an additional floor above the office section. Construction of additional beam lines, including insertion devices, will be undertaken to accommodate the heavy use and demand by outside users from industry, universities, and other laboratories.

Further details on each of these projects are provided in the construction project data sheets for Project 84-ER-111 and 84-ER-112.

	FY 1984 Request
B. Research Associated with Construction..................................	$ 5,100

Operating funds are needed for research and development to achieve the design goals of the construction projects proposed as part of this new initiative. In particular, as part of the NCAM project research is needed in two specific areas, the Advanced Light Source (ALS) and the Stanford Synchrotron Radiation Laboratory (SSRL), and research funds are also requested for support of the National Synchrotron Light Source.

The ALS consists of a 50 MeV linear accelerator, a 1.3 GeV "booster" synchrotron, a 1.3 GeV electron storage ring, and associated photon beamlines. The photon beam lines will not originate from the ring's beam bending magnets. Instead the ALS will have 12 straight sections in which special magnetic devices, wigglers and undulators, will be inserted to produce high fluxes of photons at energies ranging up to 5000 eV. A users's workshop will be held to identify projected future experimental requirements. Development of an optical ray tracing program will provide a tool to characterize the performance of these lines. R&D will be required to develop new beam lines concepts and materials for the associated mirror and grating systems. Additional R&D is needed on the fast kicker magnets and the power supplies, electron beam instabilities, and conceptual design of technical components.

At the Stanford Synchrotron Radiation Laboratory research funds are requested for soil tests and conceptual design refinements as required prior to inception of detailed design. Advanced engineering work must also be done to refine conceptual designs of components for this new beam line.

Related to the NSLS expansion, operating funds are requested to conduct research and development necessary for the construction of new beam lines. It is important to conduct research on advanced wiggler and undulators which will be inserted in x-ray and VUV rings. In addition, R&D will be performed on advanced mirrors and gratings for the x-ray microscopy and x-ray spectroscopy lines.

	FY 1984 Request
C. Forefront Research Program..	$ 4,500

Programmatic research related to the Advanced Materials Synthesis Laboratory (AMSL) will build on very strong ongoing programs in materials science at LBL. These programs, like others nationally, are handicapped by unavailability of novel and well-characterized materials for study. A particular objective of AMSL will be to create a forefront facility (for the synthesis and characterization of materials of novel or optimized physical or chemical properties); materials which may make possible devices, engines, or structures of superior performance in high technology and energy-related industries. Investigators in AMSL will collaborate with investigators in the Surface Science and Catalysis Laboratory (SSCL) by synthesizing and characterizing zeolites and novel new catalysts for investigation in SSCL. They also will collaborate with scientists and design engineers of the Advanced Device Concepts Laboratory (ADCL) by synthesizing new materials and materials of improved, controlled doping, which may make possible new device or engine concepts. For example, areas in this latter category include new superconducting-metal combinations for applications in high-temperature SQUIDS (superconducting quantum interference devices) and high-performance ceramics for use in novel design concepts that make possible the use of reliable energy efficient engine components from brittle materials.

In the metals area, research in the AMSL will emphasize synthesis of novel and new alloys. Initial work will address substitution for the strategic/critical elements of chromium and cobalt used in structural alloys such as steels. The LBL expertise on alloy design and electron microscopy will be brought to bear on designing new steels with higher strength and corrosion/wear resistance for fossil fuel-, nuclear-, and automobile-related applications. The fundamental research will be coupled with the advanced fabrication facility for processing new alloys under controlled yet industrially-relevant conditions. New materials will be evaluated primarily for physical properties needed for state-of-the-art sensors for devices, superconductors, and catalysts, among others. The resident capabilities for characterization of new materials synthesized, by electron microscopy as well as intense photons, will be a unique feature of the NCAM.

The surface modification areas will be directed towards synthesis of new materials and novel structures, exploiting the NCAM facilities for ion/laser processing and molecular beam and liquid phase epitaxy. There will be several interdisciplinary thrusts in this task: wear-hardened surface regions will be produced by both structural and chemical modification, and the deformations and fracture modes will be evaluated under difference abrasion and erosion conditions.

In the ceramics area, studies on the preparation and characterization of fine powders will be concerned with new catalyst materials such as zeolites (which are a class of compounds with porous structure), structural materials such as ZrO_2, Si_3N_4, and SiC, and complex oxide dielectrics. These sub-micron powders will be characterized in terms of their micro and surface chemistry, surface crystallographic orientation, bonding, surface area, and packing and compacting behaviors. This characterization will take advantage of the co-sited synchrotron facilities and expertise on surface characterization and behavior. Powder compaction studies will be interfaced with the related efforts and expertise on high pressure technology.

Semiconductor materials of controlled ultra-high purity and extreme crystallographic perfection will be prepared and characterized. These will include new ternary and quaternary components of the III-V and II-VI groups with controlled impurities for optimum electronic performance. These materials and their surfaces and interfaces will comprise various advanced solid-state devices. Some of them will be based on wide band-gap high temperature semiconductors, e.g., SiC, and thus supportive of the new technologies for which they are attractive.

Research related to the Surface Science and Catalysis Laboratory (SSCL), will be undertaken to further the fundamental understanding of surfaces of materials with a view toward applications and catalyzed processes on solid surfaces. The FY 1984 effort will include programs on: atomic rearrangement of surfaces, surface properties under extreme conditions and on new zeolites and novel catalyst characterization.

A theoretical and experimental effort will be initiated in FY 1984 to use techniques already developed at LBL for characterizing atomic surface structures. Theoretical predictions will be based on the pseudopotential model and related approaches, which have been perfected at LBL recently, while experiments will be performed using advanced (digital) LEED, HEED, surface EXAFS, and photoelectron diffraction. The program will later become oriented toward materials of interest for new device concepts (ADCL). Thus emphasis will shift from clean surfaces to overlayer systems (adsorbates, Schottky barriers) to atomic interfaces and three-dimensional structures. Irradiation surface structures will be altered with high-energy particles or intense photon fluxes which introduce line defects and point defects, and cause evaporation and phase transformations, including melting. Zeolites and other novel non-metallic catalysts will be synthesized and characterized using synchrotron radiation, initially at SSRL and later at ALS.

Research related to the Advanced Devices Concepts Laboratory (ADCL) will utilize the soft x-ray lithography capabilities of the Advanced Light Source (ALS) to develop new experimental devices with dimensions of 100°A or less. Success here would have an enormous effect on all electronic technology, perhaps most importantly on greatly advanced computers. The research will exploit exceptional properties of new materials in device concepts that have the potential for dramatic improvements--orders of magnitude increases in limits of sensitivities of sensors, for example, and the ADCL will investigate device concepts with potential for yielding order of magnitude improvements in characterizing material properties and behavior.

X-ray lithography success in photolithography and related studies will have an enormous effect on the understanding of the internal structure of microscopic biological systems such as cells. Research will be pursued in three dimensional solid state devices. The development of the existing two-dimensional technology in electronic circuits has led to the integration of up to one million sensing, amplifying, and switching elements on a single substrate. Three dimensional integrated circuits will have faster and more powerful operating procedures--some first ideas have already been generated. Fabrication of these novel devices will probably require molecular beam epitaxy, (MBE), deep ion implantation, capabilities within the AMSL together with x-ray lithography.

In the area of X-ray microscopy development, the increased soft x-ray intensity of the ALS should permit the imaging of living cells at times sufficiently short that resolution is preserved. The high intensity will also make possible the discrimination of low-Z elements such as carbon and phosphorous. This is of great importance to furthering our understanding of biological processes and structures, presently outside the capability of instruments using electron beams. A further development which would greatly facilitate the application of SQUIDs to a wide variety of measurements (e.g., geophysics, underwater detection, and medicine) is the design and fabrication of high temperature SQUIDs. In the area of high temperature SQUIDs, the sensitivity of DC Superconducting Quantum Interference Devices (SQUIDs) is directly limited by their size. The lithography program at ADCL will directly aid the development of more sensitive SQUIDs. Another area for research includes devices for photon generation and detection. The extraordinary brightness and time structure of ALS will require the development of novel ultrafast devices for the direct detection of a large variety of signals produced in ALS experiments. Development of novel device concepts as well as actual devices to solve these detection problems will be initiated.

For FY 1984, the equipment needed to construct ALS on schedule includes the following: Survey and alignment apparatus for tolerances of a fraction of a millimeter, equipment for ultra-high vacuum (UHV) for materials testing, RF development instrumentation in the two ranges 500 MHz and 2880 MHz, pulsed magnet equipment capable of 50 nanosecond rise times and low duty factor, low level electronics for beam monitoring, and control system equipment for hardware and software aids. Equipment for programmatic research includes advanced instrumentation for new material synthesis and characterization, e.g., a molecular beam epitaxy (MBE) system, ion-implanation and laser process instruments, and liquid phase epitaxial growth equipment. All of this instrumentation is for the advanced material synthesis in both solid and thin film form as well as for surface modification and coatings.

Chemical Sciences	FY 1982	FY 1983	FY 1984 Request
Operating Expenses	$ 63,187	$ 70,000	$ 75,500
Capital Equipment	4,940	5,510	6,520
Construction	0	400	450
Subtotal	$ 68,127	$ 75,910	$ 82,470

The Chemical Sciences subprogram supports basic research in physical, organic, inorganic, analytical and biochemistry; chemical engineering; chemical physics and atomic physics. Emphasis is currently placed on photochemistry, radiation chemistry, separations, coal chemistry, catalysis and combustion. The research is conducted primarily in national laboratories and in universities.

The principal objective of the Chemical Sciences subprogram is to expand our knowledge in the chemical and related sciences in those areas most likely to lead to new ideas and improved processes for the development and use of domestic energy resources. It is also an objective to make available to the nation highly qualified researchers with the diverse chemical insights needed to address the array of complex problems as they are encountered in the new and developing energy technologies.

Insight into the complex surface chemistry of catalysts and how it affects their activity and selectivity, for example, is needed to guide the development of new catalysts which will not be dependent on scarce or strategic materials. High quality reference grade coal and material samples, and research related to their chemical stability, are needed by the scientific community to assure comparability of results of chemical and physical measurements on them.

The scientific basis for the possible photochemical conversion of solar energy to either fuel or electricity, while promising, needs further basic research if we are to approach the state where technological development can begin. Thermodynamic data and understanding of pure constituents of gases and liquids and their effect on the properties of fluid mixtures are essential to design of economic processes. Because of the magnitude of such a measurement problem, new correlations, models and theory for predicting mixtures are particularly needed. Further understanding of combustion is expected to lead to more efficient, safer, cleaner use of fossil fuels. In the fusion program not enough is known about the physics of highly stripped ions and their interactions with plasmas.

Recent advances in the surface sciences and organometallic chemistry, and specialized facilities such as the National Synchrotron Light Source and the Stanford Synchrotron Radiation Laboratory, have opened up opportunities for synergistic advances in important energy related areas of catalysis. A like synergism is occurring in combustion science, with the Combustion Research Facility and its state-of-the-art laser diagnostics interacting in a user oriented mode with university, industrial and other national laboratory researchers.

Among the accomplishments attained in the Chemical Sciences subprogram in the past year, and reported here as examples, are several involving better understanding of catalysis, one related to nuclear waste isolation, and one involving a step forward in the fundamental understanding of phenomena important in direct conversion.

- A promising route for direct gasification of carbon to methane has been discovered. Based on alkali metal catalysis of the reaction of graphite with water vapor, it is very attractive compared to present coal gasification technology because it requires only one step instead of two and it proceeds at considerably lower temperatures. (Project jointly supported by BES and Fossil Energy).

- Clusters have been generated containing hundreds to thousands of molecules such as hydrogen and bearing an electric charge. Acceleration of such clusters and subsequent collision may lead to the conditions required for nuclear fusion. (This work was jointly supported by Chemical Sciences and Advanced Energy Projects).

- A phenomenon called "hot carrier effects", long known in semiconductor solids, was theoretically predicted (and disputed) as a solid-to-liquid phenomenon. Now this has been experimentally observed, and conceivably it could lead to a doubling in the efficiency of direct conversion photoelectrochemical solar devices. Hot carriers are electrons or positive charges, excited by light in semiconductors, which can carry excess energy into a chemical system.

- A three order of magnitude improvement has been achieved recently in the precision of measurement of the ratio, of the sulfur-32 isotope to sulfur-34 in air. It was done by the new technique of negative ion mass spectrometry. The greatly improved precision is critical to establishing the extent of anthropogenic sulfur in acid rain, which is in turn, of importance to ascribing the source of the pollution.

- A major advance in atomic physics has opened up an entirely new area of study; quasi-molecular x-ray spectroscopy. Highly energetic atomic ions are first slowed, and then collide with target atoms. At the moment of collision, x-rays are produced that can be associated with neither projectile nor target species but with a short-lived "molecule" of the two. Spectroscopy of these will add to our understanding of processes important in fusion.

- Chemical studies have led to (1) long sought-for activation of carbon-hydrogen bonds in saturated hydrocarbons, brought about by insertion of a transition metal atom between the carbon-hydrogen pair of atoms and (2) selective oxygen atom transfer to unsaturated hydrocarbons. The former may be important to activating organic groupings in coal for conversion while the latter suggests more energy efficient processes for making important chemical intermediates.

- Molecular beam experiments, supported by theoretical calculations, indicate that the reaction of oxygen atoms with unsaturated hydrocarbons leads preferentially to the formation of reactive species in which the oxygen atom has taken the place of another group in the molecule. Contrary to previous belief, carbon-carbon bond breaking does not occur. This observation will affect our perceptions of combustion chemistry.

The FY 1984 operating fund request of $75,500,000, will maintain many ongoing projects. After allowance for inflation ($3,850,000), the remainder of the increase ($1,650,000) will be used for expansion at new facilities and to strengthen basic studies in coal science with a set of premium coal samples which is essential for comparative research and analysis. The strengthening of new facilities includes the expanded operation of NSLS and the initiation there of new photochemistry, atomic and chemical physics activities; installing an LBL beam line at SSRL; and CRF operation expansion to accommodate stronger user activity. Research will continue in the following areas: catalysis, photoelectrochemistry and photocatalysis research; combustion related chemical physics; coal chemistry, and fission product chemistry research related to nuclear waste isolation.

The request for capital equipment is needed for replacement of worn out equipment and to obtain new, state-of-the-art equipment which is critical to advancing into forefront areas of science. The request also includes equipping NSLS as this unique facility comes to fuller potential and obtaining equipment needed for a new LBL beam line at SSRL in order to combine LBL's talents with SSRL's.

The construction request of $450,000 is for two accelerator improvement projects and one GPP project. The accelerator improvement projects are at ANL's Dynamitron ($100,000) in order to achieve the capabilities needed for the advanced molecular ion research there which has recently received national recognition, and at ORNL's EN Tandem ($250,000) in order to bring this former nuclear physics accelerator up to the more demanding performance requirements of atomic physics. A $100,000 GPP project at the Combustion Research Facility will strengthen its effectiveness as a user oriented laboratory and its safety.

Nuclear Sciences	FY 1982	FY 1983	FY 1984 Request
Operating Expenses	$ 22,407	$ 30,644	$ 37,900
Capital Equipment	860	1,556	2,150
Construction	0	0	270
Subtotal	$ 23,267	$ 32,200	$ 40,320

Objectives of the Nuclear Sciences subprogram are: (1) measurement, compilation, and evaluation of nuclear data for fission and fusion energy technologies; (2) improvement of our knowledge of the chemical and physical properties of the actinide elements; (3) assurance of the availability for research of both isotopically enriched samples of the ordinary elements and samples of the man-made transplutonium elements, (4) operation of the Stanford Synchrotron Radiation Laboratory (SSRL), which shares use of the Stanford Positron Electron Asymmetric Ring (SPEAR) with the High Energy Physics program. Responsibility for operation of the SSRL was transferred from the National Science Foundation to BES in FY 1983; and 5) research on heavy ion accelerator technology and preparation for its evalaution as a driver for inertial confinement fusion applications. The FY 1984 operating funds request for Nuclear Science is $38,150,000, while the capital equipment request is $1,900,000. The different activities within Nuclear Sciences are detailed below, but it should be mentioned here that the increase for capital equipment stems from (a) overdue refurbishing of the Manhattan Project-Vintage Calutrons and (b) a different mechanism for handling SSRL equipment funding following its interagency transfer.

Nuclear Data

The fission and fusion energy technologies require nuclear data for optimization of reactor design, analysis of operations and safety of reactor systems, and management of spent fuel materials. The Nuclear Data activity provides a long range base of data in support of these technologies. Nuclear data needs are documented in great detail and regularly updated: for the fission technology, through the work of the Cross Section Evaluation Working Group of the National Nuclear Data Center (NNDC) which is supported jointly by this subprogram and the energy activities Reactor Research and Technology Division; for the fusion technology, by means of a working group of the U.S. Nuclear Data Committee and direct input from the energy activities Office of Fusion Energy.

The principal element of the nuclear data measurement effort is the operation of the world-class Oak Ridge Electron Linear Accelerator (ORELA) for the measurement of neutron cross sections over a wide range of energies. Several small university groups collaborate with Oak Ridge National Laboratory staff in these measurements at ORELA. Measurement efforts are also conducted in on-campus accelerator laboratories at Duke University, Lowell University, and Ohio University. Efforts exploiting special facilities are carried out at several other national laboratories and at the National Bureau of Standards (NBS). Work devoted to the improvement of neutron standard cross sections is supported at the NBS, University of Michigan, University of New Mexico, and Idaho National Engineering Laboratory.

The compilation and evaluation effort is concerned with establishment of a data base for neutron-induced nuclear reactions and also with the maintenance of the Evaluated Nuclear Structure Data File (ENSDF) which encompasses all the information produced world-wide on the level structure and decay properties of nuclei. It is important to keep the data bases and evaluations up-to-date because of their extensive use by scientists and engineers working in the energy technologies.

Steady progress has been made in providing nuclear data of high priority to the Office of Fusion Energy since a coordinated effort was initiated in 1975. Measurements at Duke University, Ohio University, ORNL and LANL have contributed needed neutron elastic and inelastic scattering cross sections below 15 MeV. The fusion 14 MeV neutron source at LLNL has been used by Livermore staff for detailed measurements of charged-particle production using a specially designed spectrometer system. Absolute measurements of helium gas production have also been made at LLNL by a group from Rockwell International.

In FY 1984, measurement, compilation, and evaluation of data of importance to the fission reactor technologies will remain a major thrust of the nuclear data activity work and will include the development of better neutron cross section standards, as well as measurements to meet the backlog of requests for higher accuracy data for selected actinides and structural materials. However, highest priority will be given to the higher energy cross sections needed for fusion reactor designs - such as those used in calculations of tritium breeding in blankets and for radiation damage in structural materials.

The FY 1984 request for operating expenses for the Nuclear Data activity is $9,430,000, $630,000 greater than FY 1983. A strong nuclear data measurement program will be maintained. ORELA will be operated at FY 1983 levels of utilization. An increase in university participation in the data compilation effort will be implemented. Publication of the first Radioactivity Handbook based on the ENSDF data base will be achieved in FY 1984. The request for capital equipment is $380,000. It will provide for necessary replacement and upgrading of equipment, primarily at the ORELA facility.

Heavy Element Chemistry

As pointed out in the energy activities Technology Base Assessment and from workshops on environmental research of the transuranium elements, the Governmental nuclear energy and technology programs need specific information and data on the behavior of actinides in fuel processing streams, in nuclear waste hosts materials and in the environment. Heavy Element Chemistry research helps meet their needs as well as contributing to an understanding of the fundamental chemical and physical properties and behavior of matter.

Advantage is being taken of the development of spent nuclear fuel repositories which provide an opportunity to study actinide chemistry in near neutral and alkaline aqueous media as well as the interaction of actinide ions with natural sorbents and complexing species. These high priority studies provide valuable information on the behavior of actinides in the environment and for making important decisions regarding the treatment of spent fuel.

Research groups at national laboratories and universities are supported to pursue heavy element and radiochemical investigations. The study of actinide chemistry is largely limited to the national laboratories since high levels of radioactivity are involved, while some tracer work is done at universities. These laboratory facilities provide opportunities for visiting scientists from university and foreign laboratories to pursue collaborative research with the U. S. investigators. The HFIR and TRU facilities at ORNL provide for the irradiation and chemical processing of targets to produce research quantities of the transplutonium elements for chemistry and nuclear physics research by scientists in energy activity programs.

Among the more notable accomplishments in the Heavy Element Chemistry area during the past year are the following examples.

o The leaching of plutonium from candidate glass hosts for spent nuclear fuel was found to depend strongly on chemically active leachants generated in water surroundings by the high radiation field. This aspect of the effect of radiation on the glass host/water leachant system was not known heretofore.

o A comprehensive picture of the chemistry of plutonium species and certain other actinides in environmentally important aqueous carbonate-bicarbonate media has been developed. This information expands our understanding of the chemical behavior of these species as it pertains to spent nuclear fuel management.

o Studies of the binding of actinides to naturally occurring humic materials--certain organic portions of soils -- indicate that the migration of plutonium through soils rich in these materials would be very slow. Certain forms of these actinide nuclear wastes become strongly bound to the complex organic species and are essentially kinetically inert.

- The first detection of fluorescence emission from electronically excited PuF_6 has been achieved. This directly impacts the development of methods for the laser-based separation of plutonium isotopes.

Stable and Special Isotope Production

The electromagnetic isotope separators (Calutrons) provide isotopically enriched research materials for sale and loan on an international basis. These materials are used for a wide variety of medical, industrial, and research applications. The Calutrons are of Manhattan Project vintage and much of the equipment is wearing out. Thus in FY 1984 it will be imperative to provide equipment funds if they are to continue operating. Over a five year period, $250,000 per year will be needed for this purpose.

The FY 1984 operating funds request for Heavy Element Chemistry and Stable and Special Isotope Production is $16,930,000, $1,430,000 greater than FY 1983. Reflected within this request is the need to maintain a constant level of operations at the HFIR and TRU facilities and to meet the projected HFIR fuel inventory increase. The HFIR fuel inventory requirements for FY 1984 are modest but the FY 1985 requirements are expected to be about $1,900,000. Also reflected is an expansion in the study of the fundamental chemical properties of the actinides under environmental conditions. Replenishing of the stable isotope samples in the Research Materials Collection would continue at the FY 1983 level. Within the capital equipment request the increase in funds will be allocated to the Electromagnetic Isotope Separation (Calutron) Facility at ORNL to replace wornout and obsolete equipment and upgrade outdated production facilities.

In the same framework, $270,000 is needed for construction of a new and increased capacity cooling tower for the Calutrons. The tower will provide secondary water cooling for the primary closed loop oil filled system which is integral to the large magnetyokes. The replacement tower is needed not only to replace the present old and worn out one but also in anticipation of expanded production of stable isotopes to meet national needs in research and in the sales program for medicine and industry.

Stanford Synchrotron Radiation Laboratory (SSRL)

Responsibility for operation of the SSRL was transferred from the National Science Foundation to BES in FY 1983.

The SSRL was expanded under the auspices of the NSF in partial response to a National Academy of Sciences report which pointed out the great potential for research in the newly identified area of synchrotron radiation. Intense radiation in the vacuum ultra-violet and x-ray wavelength regions is given off by the circulating high energy electrons used in high energy physics research. SSRL shares equally, with the High Energy Physics program, the time and costs of operating the Stanford Positron-Electron Asymmetric Ring (SPEAR). Presently, SSRL is heavily oversubscribed by the solid state, chemical and biomedical research communities for use of its high intensity photons.

The request for SSRL operating expenses of $6,790,000 will maintain the FY 1983 level of operation of SSRL and its use by the scientific community. The capital equipment request opens new utilization possibilities, and provides for advanced dispersion devices and detectors with characteristics suited to SSRL's unique pulse time structure.

Heavy Ion Fusion Research (HIF)

The goal of the Heavy Ion Fusion Research program is to develop heavy ion accelerator technology and perform appropriate ion-beam experiments to the point where an adequate data base exists for evaluation of heavy ion inertial fusion drivers, and their possible use in civilian power applications of inertial confinement fusion.

The Heavy Ion Fusion Research program is a new program under the aegis of the energy activities Office of Energy Research, having been previously supported by the Office of Inertial Fusion (OIF) within Defense Programs. This is in accordance with Conference Report 97-342 dated November 18, 1981, on the DOE National Security and Military Applications of Nuclear Energy Authorization Act of 1982, H. R. 3413 (the Authorization Act for DOE national security programs for FY 1982), which prohibits the use of funds authorized for the defense inertial confinement fusion program for "... the research, development, or demonstration of the use of heavy ion devices...." In accordance with this Congressional guidance, the Assistant Secretary for Defense Programs and the Director of Energy Research have agreed that the "Heavy Ion Fusion Research" programs will be budgeted for in FY 1984 by the Office of Energy Research in the Energy Supply Appropriation.

Although the HIF Research program relies heavily on the theoretical and experimental groundwork developed since 1977, it is a "new initiative" in the sense that funding is sought directly for energy applications. The past accomplishments and the promise of the heavy ion accelerator approach for fusion power have been the subject of many extensive technical reviews. These have been uniformly favorable in their evaluations. However, despite the accomplishments, a number of important questions remain. A balanced program to answer these questions includes three program elements: Accelerator development and design, beam transport and focusing, and beam-target interaction. The three elements are interactive and interdependent on each other and cannot exist separately. Target design studies will continue under the auspices of OIF/DOE at the weapons laboratories. The HIF program will support accelerator and systems research which will parallel the target physics program continuing under OIF support.

Despite past accomplishments, a number of important questions remain to be answered if this idea is to be useful as the basis of an energy technology. A balanced program to answer these questions must include additional work in three program elements: Accelerator development and design, beam transport and focusing, and beam-target interaction.

A two-stage plan is envisioned. The first stage (FY 1984-1986) primarily entails the research and development of critical elements of promising accelerator technologies with particular attention to cost reduction. The second stage calls for a high-temperature experiment in which a high temperature (50-100 eV) solid-density plasma would be created. Planned for FY 1987-1989, the second stage experiment would entail the construction of an accelerator for the High Temperature Experiment (HTE). Production of high temperature in a solid-density plasma would represent a truly significant entry of accelerator technology into the parameter range needed for inertially confined fusion. It would also settle questions relating to energy deposition and beam propagation, besides providing a crucial benchmark in the development of accelerators for fusion power. Given the long-established accelerator technology history that can guarantee repetition-rate, efficiency, and reliability, HIF could then be reliably evaluated as a serious candidate for a fusion-power system for the next century.

In preparation for the high-temperature experiment, a wide range of parametric dependences need exploration before an optimum choice accelerator design can be made. In addition, it is crucial to have certain data from experimental tests on transport, acceleration, and the selected method for current amplification. Issues to be addressed in Stage I include: predicted transfer space-charge limits on beam current; stability, reproducibility, and reliability of intrapulse and pulse-to-pulse operation; accelerator cost reduction; preservation of six-dimensional phase space including stability and containment of the high charge density pulse; and final compression, transport, and focusing of the beam to the target.

The FY 1984 operating expenses request for the Heavy Ion Fusion Research program is $4,750,000 and the capital equipment is $250,000. The program represents a new initiative under the aegis of the energy activities Office of Energy Research to develop heavy ion accelerator technology that will lead toward civilian power applications of inertial confinement fusion. The Los Alamos National Laboratory will continue to serve as the lead laboratory in the Heavy Ion Fusion Research program. The principal experimental work in accelerator development and design will be located at the Lawrence Berkeley Laboratory.

	FY 1982	FY 1983	FY 1984 Request
Engineering, Mathematical and Geosciences			
Operating Expenses	$ 24,864	$ 31,050	$ 33,670
Capital Equipment	1,900	1,920	2,120
Subtotal	$ 26,764	$ 32,970	$ 35,790

This subprogram provides for the agency's principal long-term, fundamental research efforts in the disciplines of mechanical engineering, electrical engineering, applied mathematics, computer sciences, geology, geophysics and geochemistry.

Increases are requested for specific topics within these disciplines chosen for their long-term importance to meeting our nation's energy needs. In Engineering Research additional effort is required in obtaining engineering data needed for decisions on future energy technologies. In Applied Mathematical Sciences, the request provides for strengthening of research on high performance computing systems as a key element in U.S. efforts to maintain leadership in the intensely competitive area of supercomputer development. In Geosciences, the requested increase is required to augment the efforts relevant to nuclear waste isolation, and the efforts in organic geochemistry and advanced geophysical techniques.

In addition to the request for operating funds presented in the next several paragraphs, funds are requested for capital equipment including, for example, equipment for holographic measurement of flow in heat exchangers, parallel processors for research computing facilities, and detector arrays for seismic experiments. The requested funding for equipment is vital for effective research in these areas.

Engineering Research

The objectives of Engineering Research are 1) to extend the body of knowledge underlying current engineering practice in order to open new ways for enhancing energy savings and production, prolonging useful equipment life, and reducing costs while maintaining output and performance quality; and 2) to broaden the technical and conceptual base for solving future engineering problems in the energy technologies.

All the energy technologies benefit from fundamental advances in the areas emphasized in Engineering Research. Thus, for example, improved understanding of heat transfer, fluidized beds, and solid mechanics can be as pertinent to Solar or Conservation as to Fossil Energy or Nuclear Energy technologies. The same holds for basic discoveries in process control and instrumentation. Various engineering data are vital for the design of economical, reliable, and safe energy systems across the board. Such advances are the essential ingredients necessary to insure flexibility in meeting the Nation's future energy needs.

Generic energy related engineering research is filled with opportunities for significant advances. This activity seeks solutions to a broad class of fundamental energy related engineering problems in the areas of 1) Mechanical Sciences - including tribology, heat transfer, fluidized beds, and solid mechanics; 2) System Sciences - including process control, and instrumentation; and 3) Engineering Data and Analysis - including nonlinear dynamics and data bases for energy engineering systems.

Recent accomplishments in Engineering Research include:

- An advance in control system theory: Yield in some chemical processes is limited by safety considerations imposed by operating temperature and pressure limits. In a significant advance of control systems theory it has been demonstrated how the yield of catalytic reactors can be increased several fold without compromising the safety of the process plant. This accomplishment shows that vibrational control theory applies to a wider range of chemical reactors than previously expected.

- Determination of the mechanism for spread of oil spills on water: Oil spills are a well-known, extremely serious threat to the environment. Once an oil-spill occurs this threat can be mitigated only by containment and eventual cleanup. The recent determination of the details of the mechanism for spread of oil spills on water has provided understanding essential for improving spill containment methods and clues to better cleanup procedures.

- A perennial problem for the determination of fitness for service and operating safety of energy-related structures is an early detection of internal cracks. In an important achievement in the field of instrumentation needed for this purpose, a method was developed this year which allows a rapid detection of internal cracks as small as two thousandths of an inch. The method yields information about the location, size and orientation of a crack, which is needed to assess the influence of the detected minute crack on the remaining safe and useful life of the structure.

In FY 1984, $6,350,000 in operating funds, an increase of $1,000,000, are requested for Engineering Research. These funds will provide for sustaining the ongoing efforts in the three focal areas of Engineering Research, for extending work in non-linear systems dynamics emphasizing the impact of recent advances in applied mathematics on energy engineering practice; and for addressing the problem of scale up of process plants involving multiphase flows. A small, but significant, part of the funds will be used to pursue additional effort in the acquisition of engineering data needed to meet the requirements of future energy technologies, especially the thermophysical properties of fluids and the prediction of their behavior in large scale systems.

Applied Mathematical Sciences

The objective of the Applied Mathematical Sciences (AMS) research program is to advance the understanding of the fundamental concepts of mathematics, statistics, and computer science underlying the complex mathematical models of the key physical processes in energy systems. The AMS program funds basic research at many of the national laboratories, universities and private research institutions in three major categories: analytical and numerical methods, information analysis techniques, and advanced computing concepts. Special studies conducted by members of the National Academy of Sciences at DOE's request help identify new thrusts and program priorities.

Much of the scientific research and development effort supported by BES is focused directly on analytical and numerical modeling of physical processes. Without an understanding of the fundamental principles upon which these models are based there is no possibility of making any significant progress in developing energy systems for the future. The results of analysis, algorithm development, and development of computational techniques are crucial to the conduct of scientific research.

Recent AMS accomplishments include the following:

- A result of great power and importance has emerged from research at Los Alamos on the mathematical theory of dynamical systems. Many systems such as ones involving convective flow become chaotic under some circumstances. The laminar flow becomes turbulent. The new result shows that for a wide variety of systems, the onset of chaotic phenomena follows a precise law independent of the size, boundaries or other details of the system. Hence observation of simple systems can be used to model systems which in the past seemed overwhelmingly complex. Further, the new result can be applied not only to turbulent flow but also, for example, to chemical oscillators and Josephson junction devices.

- New ways have been found to apply the mathematical description of the phenomena called bifurcation--the transition of a system from one stable state to two other, coexistent states with differing properties--to a model explaining recent observations on the several modes of burning of solid fuels.

- In a project called AURORA (Automated Reasoning on Reactor Analysis), a collaboration between Argonne and Northern Illinois University, the automated reasoning program was able to prove, as required for nuclear plant licensing, that single component failures could not inhibit shutdown.

The FY 1984 operating budget request for Applied Mathematical Sciences is $14,670,000, an increase of $820,000 over the amount requested in FY 1983. The research will remain focused on the concepts underlying large-scale computational modeling of processes in energy systems. There will be a continued emphasis on the support of the algorithm, language, and architecture aspects of high performance parallel computing systems for scientific computation. This will support a coordinated effort by the best research teams capable of maintaining U.S. leadership in supercomputers, an area of intense international competition. Some additional support for analysis of the mathematics of non-linear systems will be possible. Support for computational mathematics and statistics will be continued at present levels.

Geosciences

The Geosciences activity supports long range research in geology, geophysics, geochemistry, rock mechanics and tectonophysics to develop, in areas pertinent to the nation's energy needs, a quantitative and predictive understanding of processes in the earth and the solar terrestrial interface.

As the traditional sources of energy supply diminish, alternatives must be found. Further, the extraction and use of energy resources result in wastes, the safe disposal of which requires continued fundamental research. The earth and the sun are the sources of the world's energy supply. The earth and its atmosphere are the sinks for the wastes generated. Thus, the development of an adequate base of knowledge in the geosciences is critically needed for energy resource recognition, evaluation and utilization in an environmentally acceptable manner.

Several new directions in which this base of knowledge should be extended have become evident. A workshop in organic geochemistry identified a number of priority research areas of high scientific and programmatic interest. Seismic activity, tectonic uplift and increased fumarolic activity at Long Valley-Mono Craters has opened a second area for detailed site study in the Continental Scientific Drilling Program (CSDP). The need for in situ geophysical and geochemical information has increased the need for research in advanced geophysical techniques.

Geosciences supported research is carried out principally at the national laboratories and at universities. The program supports long range disciplinary research chosen for its special significance to present and future energy technologies. For example, coordinated projects in nuclear waste isolation and Continental Scientific Drilling address directly and indirectly long range national energy concerns. Studies of subsiding basins, their time, temperature and tectonic history are leading to a better understanding of the development of energy resources in nature and thus to their more effective exploitation. Development of new geophysical methods and of computer codes for improved modeling of geophysical data and their use in resource exploration are leading to improved methods of locating resources and identifying sites for waste isolation. Geochemical studies of element migration and energy and mass transfer is providing the knowledge base needed to understand the mechanisms of energy and mass transfer in hydrothermal systems, the movement of radio-nuclides from a repository, and the concentration and location of resources. Research in organic geochemistry is yielding an improved understanding of the origin, development and emplacement of gas, oil, and coal deposits, to identify the sources of pollutants in these resources and may suggest ways of dealing with them.

Recent Geosciences accomplishments include the following:

- o Computer modeling studies at Sandia National Laboratories indicate that water-biomass mixtures can be efficiently converted to higher quality gaseous fuels by the very high temperature heat derived from magma bodies.
- o Research at the Argonne National Laboratory has shown that Columbia River basalts have a pronounced reducing effect on neptunium in the hexavalent state. The reduced states are highly adsorbed on the surface of the basalt, a favorable factor for the immobilization of nuclear waste in deep repositories in basalt.
- o Studies at the Lawrence Livermore National Laboratory have shown that the electrical conductivity of oil shale during retorting is a billion times greater than its value before or after retorting. Because highly conductive material inside insulators can readily be detected with radio waves, the retorting zone of an underground body of oil shale may be mapped remotely.

The request for FY 1984 operating expenses of $12,650,000, an increase of $800,000 over FY 1983, for the Geosciences program provides for continuation of the research efforts in Geology, Geophysics and Earth Dynamics, in Geochemistry, in Energy Resource Recognition, Evaluation and Utilization, in Hydrologic and Marine Sciences and in Solar-Terrestrial Atmospheric Interactions with emphasis on continential structure and dynamics (Continental Scientific Drilling Program), on long-range, basic studies pertaining to the isolation of nuclear wastes and on organic geochemistry.

	FY 1982	FY 1983	FY 1984 Request
Advanced Energy Projects			
Operating Expenses	$ 7,310	$ 8,300	$ 9,100
Capital Equipment	320	290	310
Subtotal	$ 7,630	$ 8,590	$ 9,410

The objective of the Advanced Energy Projects 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 a high risk; to qualify for support they must also have the potential for an eventual high pay-off. Also supported is exploratory research on concepts that do not fit easily into the existing energy activities program structure. An area of major programmatic attention is the transfer of successful projects to appropriate technology programs or to the private sector; one or two such transfers now are effected every year.

The need to support exploratory research on novel concepts of the type described above is to provide the seed for technical innovation. However, such research does not generally qualify as basic research, where the objective is to gain knowledge and understanding of processes and phenomena in nature. Neither does it qualify as technology-related: the link with any specific technology needs yet to be established. Hence, the Advanced Energy Projects subprogram fills a very real void between basic and technology-related research.

The subprogram takes advantage of opportunities resulting from advancements in basic science. Thus, for example, advancements in the physics of ionic conductors--ceramic materials that conduct ions but not electrons--have lead to an altogether new and potentially advantageous scheme for directly converting heat to electricity; that scheme was recently demonstrated on a laboratory scale in a device called a sodium heat engine. The Advanced Energy Projects subprogram supports several projects in the area of innovative approaches to direct heat-to-electricity conversion.

The mode of operation for this interdisciplinary, and still relatively new, subprogram is to support individual projects for a limited time only; it differs from other subprograms in that it does not fund ongoing evolutionary research. The spectrum of projects supported is very broad, encompassing, for example, new approaches to uranium separation, totally new approaches to controlled fusion, new methods of oil recovery from shale, and new approaches to solar energy collection and concentration, just to name a few. Close contact is maintained with 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. At present, about forty projects are being supported, which allows a turnover rate of about thirteen projects a year.

A recent accomplishment of Advanced Energy Projects is the demonstration of scientific feasibility of batteries, both storage and primary, with electrodes made of light polyacetylene sheets (rather than, say, lead). This discovery can pave the way to a whole new technology and drastically change the outlook for electrically powered vehicles.

Last year brought evidence of an increasing recognition of Advanced Energy Projects as an important vehicle in promoting science-based technical innovation.

- o At a symposium on x-ray lasers held by the American Physical Society in April 1982, three out of four invited speakers were supported by Advanced Energy Projects.
- o Committee on Applications of Physics of the American Physical Society resolved to hold in March of 1983 a Symposium on Advanced Energy Projects. All five invited speakers are Principal Investigators on projects supported by this subprogram.
- o The Advanced Energy Projects subprogram initiated presentations of selected successfully completed projects at the annual Energy Technology Conference and Exposition in Washington, D.C. Those presentations attracted wide attention and resulted in concrete steps towards effecting the transfer of the respective technologies.
- o Several successfully completed projects have been picked up for further development either by industry or by other programs within the Government.

The Advanced Energy Projects subprogram is requesting $9,100,000 in operating expenses and $310,000 in capital equipment funds. The requested budget level will permit 13 new initiatives and represents a step towards attaining the goal of supporting 20 new initiatives per year.

	FY 1982	FY 1983	FY 1984 Request
Biological Energy Research			
Operating Expenses	$ 8,419	$ 9,500	$ 10,580
Capital Equipment	410	370	400
Subtotal	$ 8,829	$ 9,870	$ 10,980

The Biological Energy Research subprogram objectives are 1) to define basic biological phenomena and mechanisms in plants and microbes that relate to future enhanced biomass productivity and bioconversion of the most abundant materials such as cellulose, lignin and hemicelluloses; 2) to generate the underlying information for developing novel or improved fermentations for fuels and chemicals; and 3) to understand principles of biological phenomena which may be applied for energy conservation measures.

There have been numerous references in financial journals to heightened expectations that biotechnologies are to become one of the major new industries as the end of the 20th Century draws near. These projections are based on conceptual and technical advances in biology which have occurred in the last decade or so. These include recombinant DNA technology, cell and tissue culture procedures and broad progress in other biological areas. Such developments in biotechnology would touch not only medicine and the chemical and drug industry but also agriculture and certain parts of the energy industry. These developments will affect renewable resources such as biomass production and bioconversion, but there are good prospects as well for using biosystems in pollution control and in recovery of strategic materials from ores which otherwise require sizable amounts of energy for processing. Other biosystems may also prove to be important in an energy conservation mode. However these developments will not materialize in a timely and effective manner unless the base of fundamental biological information is developed. Biological Energy Research is unique in the federal research system designed to address these needs.

The Biological Energy Research subprogram is aimed at comprehending the limits to productivity in green plants (biomass) beginning with studies on photosynthesis, the key solar energy conversion process, and continuing with investigations on mechanisms of growth and development with emphasis on effects of and adaptation to stress by plants. The mode of transmission and expression of genetic information also receives emphasis. In the area of microbiology the subprogram is oriented towards understanding how various organisms degrade the abundant biopolymers cellulose, lignin and hemicellulose. In particular, understanding the conversions carried out by anaerobic organisms and those performed by thermophilic (high temperature) organisms are current goals. Such processes as methanogenesis which usually involve multiple species are given emphasis with respect to the interactions and interchanges biochemically between the organisms in the consortium. The genetics of organisms of importance in fermentations and other conversions but hitherto not studied genetically receives support. About 75% of the research is conducted at universities, 25% at national laboratories.

Some examples of recent research accomplishments include:

- A new pathway of energy conversion using inorganic phosphorous as a substrate has been discovered in anaerobic bacteria. The finding may result in a way of enhancing reaction rates in anaerobic digestors and sewage treatment systems to produce methane gas.

- Progress has been made in determining how plant systems sense temperature. A model has been developed based on evidence deriving from mutants suggesting that temperature perception is a balanced operation of two temperature sensors, one operative at the high end and the other at the low end. The molecular nature of these sensors is as yet unknown. This work is important since plants initiate adaptive processes in response to environmental sensing; conceivably this knowledge could be used ultimately to artificially adapt plants for specific environments.

- Growth regulation in plants adapted to sustained flooding has recently been clarified. Ethylene, a substance which has growth regulating properties is frequently produced by plants under stress. It is synthesized by certain plants in response to flooding. The ethylene thus produced induces pronounced rapid elongation of the plant sufficient to maintain contact with the atmosphere, without which the plant dies.

- A water soluble product from the fungal degradation of lignin has recently been isolated which is called acid precipitible polymeric lignin. This product has not been observed previously and could serve as a potentially valuable industrial chemical. A patent for this product is pending.

The specific areas of emphasis in FY 1984 include:

- Mechanisms of stress adaptation in plants
- Cellulose biosynthetic and biodegrading mechanisms
- Genetics of anaerobic microbes
- Microbial surface phenomena as related to immobilization and interfacing activities

The FY 1984 budget request is $10,580,000 for operating expenses and $400,000 in equipment. Increases sought will permit entry into a few research areas not previously supported (e.g., surface interactions of microorganisms) and would also allow the required strengthening of research efforts that have been initiated in recent years (e.g., genetics of anaerobic microorganisms, stress mechanisms in plants).

	FY 1982	FY 1983	FY 1984 Request
Program Direction			
Operating Expenses	$ 2,500	$ 3,100	$ 3,970
FTP/Total FTE's..................................	52/56	54/60	58/62

The FY 1984 budget request for Basic Energy Sciences Program Direction is $3,970,000. These funds are required to provide for the salaries, benefits, travel and related expenses associated with the 62 full-time equivalents (58 full-time permanent, 4 other than full-time permanent) required to administer and support this program. This staffing level represents an increase of 2 full-time equivalents above the revised FY 1983 level. The increased funding is to provide for the additional full-time equivalents and normal increased personnel costs such as within-grade and merit increases, benefits and other support costs associated with programmatic increases. The increased funding further reflects the impact on average salaries of the FY 1982 and FY 1983 pay cap increases and two general pay increases in FY 1982 and FY 1983.

Basic Energy Sciences is a broadly diversified program responsible for mission-oriented research, the chief purpose of which is to provide the fundamental scientific and engineering base on which the Nation's future energy options depend. Its staff must possess expertise covering many subfields in the areas of chemistry, physics, engineering, metallurgy, geosciences, biology, mathematics and computer sciences, as well as in administration, procurement and financial management. The staff is responsible for development, direction, and management of complex technical programs, each involving one or more of the scientific areas mentioned above. Their activities include assessing scientific needs and priorities of the program, developing long-range program plans, technical review of proposals from laboratories and universities, monitoring the progress of ongoing university contracts, laboratory programs, and construction projects.

It is extremely important to appreciate the diversity and scope of the research effort involved in the Basic Energy Sciences program in order to understand the need for and justification for the requested level of Federal staffing. In FY 1983, for example, approximately 1,200 research projects will be underway either at agency laboratories or at more than 150 colleges or universities in 45 states. Therefore, each BES program official has a considerable number of projects to oversee. Evaluation, monitoring and management of this large number of diverse projects primarily from the Headquarters requires continuous contact with the contractors and laboratory staff and involves numerous workshops, planning meetings, and project reviews throughout the year.

The Basic Energy Sciences budget has continued to grow, and the FY 1984 request represents a significant increase above the FY 1982 level. At the same time, staffing during the past several years has remained constant. During recent years research projects at universities have increased from 18 to 26 percent of the BES budget, and the workload per university project is significantly greater than that for a laboratory project. This is especially true with regard to evaluation of proposals, of which approximately 10 percent of those reviewed are for new contracts each year. The result is that increased staffing resources are becoming more and more critical to maintain a strong core program, to evaluate expanding research programs in newer emerging priority areas having great potential importance to energy, to oversee management and operation of existing and new unique research facilities, and to promote early application of the results of this basic research.

In addition to the ongoing basic research program, this staff has been charged with management of the newly mandated three-phase Small Business Innovation Research (SBIR) program (Public Law 97-219). The law requires implementation of Phase I in FY 1983 which is expected to yield as many as 10,000 requests for the solicitation, resulting in approximately 1,000 proposals spread among 25 technical topics, and awarding of 100 contracts for up to $50,000 each. Workload in FY 1984 is expected to increase further, as approximately one-half of the FY 1983 Phase I awards go into Phase II and new Phase I awards are also made.

The FY 1984 request, therefore, reflects an increase of two full-time equivalents above the revised FY 1983 level to support programmatic growth and strengthening of research efforts across the board, but primarily in Materials and Chemical Sciences activities. This additional staff is required to support major new thrusts recommended by workshops and panels of the Council on Materials Sciences; to review and evaluate the efforts resulting from expanded operation of the NSLS, including the new initiative to provide greater access by industry and university users, and the WNR/PSR-LANL facility and full operation of the LBL Center for Electron Microscopy; and to strengthen selected high priority chemical research activities. This staff is also now responsible for managing operation of the Stanford Synchrotron Radiation Laboratory which was transferred from the National Science Foundation in FY 1983. In addition, establishment of a National Materials Research Center at LBL (TEC $138,900,000) will begin in FY 1984 to improve the linkages among academic national laboratories and industry scientists in the future advancement of high technology industries. In total the number of research projects to be managed by BES staff is expected to increase to nearly 1,300, excluding the SBIR program. The staff must implement and manage the SBIR program and continue to maintain close interaction with all of the technical programs of DOE, related R&D programs in other agencies, and special studies and assessments sponsored by the National Academy of Science and the scientific societies.

DEPARTMENT OF ENERGY
Energy Supply Research and Development
Basic Energy Sciences
(dollars in thousands)

Project Number	TEC/ TPC	Project Title and Location	Phase	Funds Appro- priated To Date	Total Obligations Planned	Total Obligations Actual	Total Cost Planned	Total Cost Actual	Remarks
84-ER-112	$138,900 $174,100	National Center for Advanced Materials, Lawrence Berkeley Laboratory, Berkeley, California and Stanford Linear Accelerator, Stanford, California	Construction	$0	$0	$0	$0	$0	

Department of Energy
FY 1984 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: Beam lines and support area construction
National Synchrotron Light Source (NSLS)
Brookhaven National Laboratory, Upton, NY

2. Project No. 84-ER-111

3. Date A-E work initiated: 1st Qtr. FY 1984

3a. Date physical construction starts:

4. Date construction ends:

5. Previous cost estimate:
Less amount for PE&D:
Net cost estimate:
Date:

6. Current cost estimate: $19,700
Less amount for PE&D: 0
Net cost estimate: $19,700
Date: 2/82

7. Financial Schedule:

Fiscal Year	Authorization	Appropriations	Obligations	Costs
1984	$19,700	$ 2,500	$ 2,500	$ 2,200
1985	0	11,000	11,000	7,830
1986	0	6,200	6,200	9,670

Work included for accomplishment with the first year's appropriation of $2,500,000 will include but not be limited to the design and engineering of beam line components and preliminary and detail design of the support area construction.

8. Brief Physical Description of Project

Current program planning anticipates the need for the beam lines listed below. However, programmatic requirements together with the state of the art at the time of construction may require a variation of the type and number of beam lines that would be most beneficial to the facility.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project:	Beam lines and support area construction National Synchrotron Light Source (NSLS) Brookhaven National Laboratory, Upton, NY	2. Project No. 84-ER-111

8. Brief Physical Description of Project (continued)

3 'Wiggler' lines
1 X-ray fluorescence microscopy line
1 X-ray core level spectroscopy line
1 Undulator for UV radiation
1 Line for medium and high resolution photoemission spectroscopy
1 Lithography line
1 Line for high resolution UV spectroscopy.

The project also provides for the design and construction of building space to house technical work areas and offices in support of these and other beam lines.

A. New Experimental Equipment

This project provides for an expansion of experimental capabilities which will be made available to general users at universities, industry, national and Government laboratories. Researchers will come from many disciplines with largest use from materials scientists, but with sizeable participation by biologists and chemists and other disciplines.

The new equipment to be provided will take maximum advantage of the properties of synchrotron radiation. The present programs needs are:

1) 3 multipole wiggler magnets together with associated experimental equipment. These magnets will be installed in straight sections of the x-ray ring and will provide copious X-rays at wavelengths as short as 0.1 A (energies as high as 100 keV). Radiation in this energy range will expand the capabilities of the facility beyond those provided by the radiation from standard beam ports.

2) A spectrometer for fluorescence microscopy. This device will use the high degree of brightness and tunability of synchrotron radiation to detect very small concentration of elements in a sample for materials, chemical, biological, and technical applications.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: Beam lines and support area construction
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2. Project No. 84-ER-111

8. Brief Physical Description of Project (continued)

3) A spectrometer for core level spectroscopy to be installed at the X-ray ring.

4) A multipole undulator and beamline front end to be installed in the VUV ring. This device, similar to a wiggler, will provide ultraviolet radiation more than 20 times as intense as that available at beam ports at the bending magnets. This increase in intensity will make possible studies of very dilute samples (e.g., gases or molecules deposited on surfaces).

5) Spectrometers for medium and high resolution UV spectroscopy.

6) A line to use UV radiation for lithography. This facility will provide users with the means to test the applicability of synchrotron radiation for the fabrication of small scale integrated circuits.

7) A high resolution gas phase spectrometer. This will be installed at the VUV ring for atomic and molecular physics studies.

A final decision on the specific beam line construction program will be made in the light of users needs at the start of construction.

B. New Building Addition

The proposed addition to the NSLS building will provide approximately 47,300 square feet of support space and promote increased utilization of the NSLS facility. The technical staff will move to new work areas, making more space available for the new beam lines. Extending the experimental space adjacent to portions of the VUV and X-ray storage rings will allow a number of long beam lines to be constructed, permit additional branching of existing ports, and give needed space to users for specialized support equipment.

The proposed expansion will be generally at the north side of the building. It will be a two-story structure of which about 24,000 square feet will be at the first floor level and contiguous to more than 30% of the perimeter of the X-ray experimental floor. Since the floor will be at the same level as the existing building, it will be possible to extend the lengths of up to three primary X-ray beam lines. The building will contain work areas for vacuum, instrument, and electronics technicians, and a staff shop for up to six machinists, all of whom will serve VUV and X-ray experimental users.

8. Brief Physical Description of Project (continued)

The second floor will contain about 8,000 square feet, devoted principally to offices but with some space for workrooms and laboratories. Part of this space will be used by visiting research teams and part by the NSLS staff.

The VUV portion of the building will be expanded with the addition of about 5,600 square feet of experimental and support area including a receiving area to service VUV experimental equipment and a mezzanine. The expansions will provide important space for staging and possible extension of VUV beam lines. The addition of the mezzanine can easily be done since the building has a headroom of 18' - 0" in this area. The mezzanine can be used for vertically-deflected experiments or for support space.

A new third floor over the existing two-story building will add about 7,800 square feet. This will provide essential office space for approximately 26 people, a design/drafting area and miscellaneous support areas. This addition will cause a minimum of disturbance to the existing facility because a 'third floor option' was structurally built into the original design.

A tunnel, about 80 feet long (800 square feet), will connect this building with the basement of the adjacent Safety and Environmental Protection building. Part of the basement of this building contains important NSLS work and laboratory areas, including a clean room and X-ray and VUV sources for testing experimental equipment. The tunnel will integrate this valuable space with the NSLS building.

The expanded building will be designed to at least the same energy conservation standards as the existing one and contain a similar fire protection sprinkler system. Access by handicapped persons to the new third floor will be provided by extending the present elevator.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project:	Beam lines and support area construction National Synchrotron Light Source (NSLS) Brookhaven National Laboratory, Upton, NY	2. Project No. 84-ER-111

8. Brief Physical Description of Project (continued)

C. Existing Facility

The NSLS consists of two electron storage rings, an injection system common to both, experimental beam lines, experimental equipment, and office and support area all of which is housed in a 74,000 square foot building.

The high energy X-ray storage ring provides for the possibility of 28 primary beam ports, each of which is capable of accommodating several experimental beam lines. The VUV ring provides for 16 beam ports which are also capable of accommodating several experiments each. In sum, more than 90 experiments can be carried out at one time when the facility is fully instrumented. In addition to general users, research groups called Participating Research Teams (PRT's) from universities, industry and national and Government laboratories, upon advice by a program committee, and approval by the Brookhaven National Laboratory (BNL) directorate, provide instruments to carry out research programs at the NSLS facility. Their instruments are made available to general users for 25% of the available experimental time. At present, such groups provide an additional 20 experiments at the facility. General users are able to use any of the experimental lines, PRT or community lines, upon approval of their experimental proposal.

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

The NSLS is operated as a user facility. This means that researchers from BNL and other laboratories are able, after review of a proposal by a committee of distinguished scientists, and acceptance by the BNL Director, to carry out experiments using either the UV or X-ray radiation produced by the rings.

The response from users,both within BNL and outside, has placed a demand on the NSLS facility far surpassing its present resources. The limited beam lines which will be available combined with the limited space available makes expansion of experimental research within the present confines of this facility unpracticable. In order to support further development of this facility it will be necessary to provide additional floor, laboratory, and staging space. An experimenter should have a choice of a wide range of instruments which he can utilize for this research. To provide this choice, two types of instruments are proposed:

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Brookhaven National Laboratory, Upton, NY

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

a) A group of instruments that will be available to general users that will complement in capability those already provided, and;

b) Several instruments (wiggler magnets and an undulator) which will provide a range of wavelength and intensity not available at the bending magnets. These instruments will be used both by general users and by members of the PRT's who will require such augmented capabilities for their experiments.

A. New Experimental Equipment

In the original development plan, provision was made for a total of eight beam lines to be available to general users. Additional beam lines were to be provided at the rate of about two a year out of capital funds. Further instrumentation was to be made available by PRT's, who would install beam lines at the rings at their expense and who would make 25% of the experimental time on those lines available to general users. However, the growth in user participation has far exceeded earlier expectations.

In order to provide experimental capabilities required both by PRT's and by general users, it is proposed to accelerate beam line construction. It is particularly important that the capabilities provided for in this project, such as wiggler magnets, be made available at the earliest possible date.

In addition to satisfying the requirements of the users, the accelerated design and construction of these beam lines will provide a cost saving because of efficiencies in planning, design, and construction.

B. New Building

The design for the NSLS building emphasized long term space requirements for the accelerator/storage rings and the equipment associated with their control and operation. Adequate space for experimental beam lines around the VUV and X-ray storage rings was also provided, although future long beam lines that extended beyond the building walls were regarded as a possible future option.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project:	Beam lines and support area construction National Synchrotron Light Source (NSLS) Brookhaven National Laboratory, Upton, NY	2. Project No. 84-ER-111

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

The space for the machine and experiments was given highest priority in initial design, while support areas were provided to satisfy requirements for projected use during the initial years of operation. A possible expansion of experimental support areas, work areas, and offices and was allowed as a future option. Therefore, only minimal space was given to several general laboratories, the second floor office-administration area, and other support areas.

It was projected that during the early years of operations, up to approximately 50% of the 28 X-ray and 16 UV ports would be utilized. The extremely enthusiastic response of the scientific community now forces us to advance the expected rate of beam line construction and building expansion. More than 20 experiments have been proposed by PRT's for construction at an early date. This response, coupled with the community beam lines to be provided by the project, indicate that the experimental floor will be extremely crowded after October 1983 and additional support space will be essential.

The original design anticipated a possible need for future expansion. The building frame was designed to support a third floor over the office administration wing. Site utility lines were kept at least 30 feet from the building foundation. Adequate space was left between the NSLS buildings and the Safety and Environmental protection building.

In addition to the pressing need to return experimental floor space to its intended use, the expansion will provide adequate office space for the permanent staff and work areas to complement the research and development associated with the anticipated experimental and machine improvement programs. The short connecting tunnel between the NSLS building and the basement of the adjacent Instrumentation building will connect the NSLS staging areas to an area where now extensive NSLS vacuum, instrument, and diagnostic work is in progress and where UV and X-ray test sources are located.

Annual Costs

The estimated incremental operating costs of the proposed NSLS beam lines and support area construction are listed below. Costs are in the FY 1984 dollars.

	(Dollars in Thousands)
Materials, Supplies, Support Services	$ 94
Electric Power	150
General and Administrative	44
Total	$288

CONSTRUCTION PROJECT DATA SHEETS

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10. Detail of Cost Estimate[a/][b/]

	Item Cost	Total Cost
a. Engineering, design and inspection, including A-E fee (approx. 21% of item c)..........	$	$ 2,830
b. Land and land rights..........		0
c. Construction costs..........		13,375
(1) Beam line construction..........	6,450	
(2) Improvements to land..........	100	
(3) Building..........	6,660	
(4) Tunnel to S&EP building..........	95	
(5) Utilities..........	70	
d. Standard equipment..........		685
Subtotal..........		16,890
e. Contingency, approximately 17% of above costs..........		2,810
Total Project Cost..........		$ 19,700

[a/] Estimate is based on a complete conceptual design.

[b/] Escalation rates conform to the guidelines prescribed in the Department of Energy Field Budget Process Chapter, February 1982, which are based on the materials and labor data contained in the Energy Supply Planning Model and escalation rates forecasted by Data Resources, Incorporated (DRI). Current costs have been escalated by 9.3%, 9.1% and 8.4% per year for FY 1983 through FY 1985.

11. Method of Performance

This type of construction is unique and therefore the conceptual design, final design, assembly and testing will be done by the staff of the National Synchrotron Light Source of the Brookhaven National Laboratory. Component parts wherever possible will be fabricated by industry under fixed priced competitively obtained procurement actions. Some components may be fabricated in the existing shops at BNL. It is also anticipated that other laboratories, private consultants, and industrial firms will be used for advice on specific problems. Building design will be on the basis of a negotiated architect-engineer contract and its construction will be by a competitively obtained lump sum contract.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: Beam lines and support area construction
National Synchrotron Light Source (NSLS)
Brookhaven National Laboratory, Upton, NY

2. Project No. 84-ER-111

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

	Prior Years	FY 1984	FY 1985	FY 1986	Total
a. Total project costs					
1. Total facility costs					
(a) Construction line item.........	$ 0	$ 2,200	$ 7,830	$ 9,670	$ 19,700
(b) CP&D...........................	0	0	0	0	0
(c) Expense Funded Equipment.......	0	0	0	0	0
(d) Inventories....................	0	0	100	100	200
Total facility costs............	0	2,200	7,930	9,770	19,900
2. Other project costs					
(a) R&D necessary to complete construction of beam lines....	900	500	500	0	1,900
(b) Other..........................	0	0	0	0	0
Total other project funding....	900	500	500	0	1,900
Total project funding..........	$ 900	$ 2,700	$ 8,430	$ 9,770	$ 21,800

b. Total related funding requirement (estimated life of project: 17 years)

1. Operating costs..	$ 288
2. Programmatic operating expenses directly related to the facility........	0
3. Capital equipment not related to construction but related to the programmatic effort..	0
4. GPP or other construction related to the programmatic effort...........	0
5. Other costs..	0
Total other related annual funding requirements........................	$ 288

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: Beam lines and support area construction
National Synchrotron Light Source (NSLS)
Brookhaven National Laboratory, Upton, NY

2. Project No. 84-ER-111

13. <u>Narrative Explanation of Total Project Funding and Other Related Funding Requirements</u>

a. Total project funding
   1. Total Facility
      (a) Construction line item - no narrative required.
      (b) CP&D - no narrative required.
      (c) Expense funded equipment - no narrative required.
      (d) Inventories - it is anticipated that funds will be required for the procurement of special process spares.
   2. Other project funding
      (a) R&D necessary to complete construction - funds provided in the NSLS R&D budget. This item gives estimates of the R&D necessary to develop the monochromators, mirror systems, target chambers, detectors and superconducting structures for high field wigglers and undulators.
      (b) Other - no narrative required.

b. Total related funding requirements
   1. Operating Costs - There will be an annual requirement of additional materials, supplies, and support services associated with the new beam lines. Also, there will be a requirement for increased facility electrical power.
   2. Programmatic operating expenses directly related to the facility - no narrative required.
   3. Capital equipment not related to construction but related to the programmatic effort - no narrative required.
   4. GPP or other construction related to the programmatic effort - no narrative required.
   5. Other costs - no narrative required.

Department of Energy
FY 1984 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: National Center for Advanced Materials, Lawrence Berkeley Laboratory, Berkeley, California and Stanford Linear Accelerator Center, Stanford, California

2. Project No. 84-ER-112

3. Date A-E work initiated: 1st Qtr. FY 1984

3a. Date physical construction starts: 1st Qtr. FY 1984

4. Date construction ends: 4th Qtr. FY 1989

5. Previous cost estimate: None

6. Current cost estimate: $138,900
Date: 12/82

7. Financial Schedule:

Fiscal Year	Authorization	Appropriations	Obligations	Costs
1984	$138,900	$ 25,900	$ 25,900	$ 17,000
1985		26,600	26,600	30,000
1986		26,700	26,700	27,300
1987		29,400	29,400	27,400
1988		23,300	23,300	28,400
1989		7,000	7,000	8,800

8. Brief Physical Description of Project

The proposed National Center for Advanced Materials (NCAM) will be located on University of California property adjacent to the Berkeley campus, within the site of the Lawrence Berkeley Laboratory. The project will include the construction of new facilities, and the alteration of, and additions to, existing facilities. Plant and site facilities will consist of: a) improvements to land, including grading, drainage, paving, lighting, and walkways; b) a new Surface Science and Catalysis Laboratory (SSCL) building (47,500 GSF); c) a new 82,000 GSF building for both the Advanced Materials Synthesis Laboratory (AMSL) and the Advanced Device Concepts Laboratory (ADCL); d) the removal of shielding blocks and certain utilities from 30,000 GSF of existing space in Building 6 and the addition of 28,000 GSF to Building 6 to house the Advanced Light Source, a special facility comprised of an electron storage ring and injection system, insertion devices for generating synchrotron radiation beams, and photon beams.

8. Brief Physical Description of Project (continued)

A complementary program at the Stanford Synchrotron Radiation Laboratory (SSRL) will provide for the construction of equipment to increase the brightness of synchrotron radiation beams from the existing 4-GeV SPEAR storage ring, for the construction of a 13,200 GSF building addition at SPEAR, for the construction of wiggler and undulator insertion devices and new beamlines at SPEAR and the existing 16-GeV PEP storage ring, and for equipment to improve injection into SPEAR and to eliminate effects of ground vibrations on SPEAR performance.

a. Conventional Construction

The Surface Science and Catalysis Laboratory will be a 3-story building that will have a reinforced-concrete frame, shear walls, waffle roof-and-floor structure supported on spread footings.

The ALS-related addition to Building 6 will be a high-bay, single-story, industrial building comprised of a heavy-duty concrete floor slab with a braced steel frame and a metal deck roof with insulation and built up roofing. The proposed AMSL/ADCL L-shaped 4-story building will occupy a hillside site providing a first floor with a main entrance at the grade level of the base of the hill. The third floor will align with, and provide direct access to, the lower floor of Building 80, a 2-story building housing the ALS control room, shops, staging areas and support facilities for the ALS.

At SSRL, laboratory and office spaces on two levels will be added on the south arc of the SPEAR ring. A beam line tunnel will be constructed from the PEP ring to a small underground experimental hall, and an access tunnel will be constructed to the experimental hall.

b. Special Facilities (The Advanced Light Source)

The Advanced Light Source (ALS) is the first accelerator designed explicitly to utilize insertion devices (wigglers and undulators) to provide increased photon brilliance (10,000 times better than existing synchrotron light sources); the accelerator also provides photon pulses having a very short pulse length (tens of picoseconds). The ALS consists of a 50-MeV electron linear accelerator, a 1.3-GeV booster synchrotron, a 1.3-GeV electron storage ring, and a number of photon beam lines extending from the insertion devices. Major components of the 170-m-Circumference storage ring are some 24 bending magnets and 84 focusing magnets. Special facility work at SSRL includes technical modifications and additions for SPEAR and its injection system so as to meet enhanced performance objectives, construction of in-vacuum insertion devices for the SPEAR and PEP rings, and components for the PEP undulator beam line.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: National Center for Advanced Materials, Lawrence Berkeley Laboratory, Berkeley, California and Stanford Linear Accelerator Center, Stanford, California

2. Project No. 84-ER-112

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

This research center is proposed as a scientifically logical redirection of the Lawrence Berkeley Laboratory with complementary augmentation of capabilities at SSRL, to address a vital national need, to accelerate basic research in an area that promises medium-term impact on high-technology industries, and to foster closer ties between national laboratory researchers and their counterparts in industrial and university laboratories. The NCAM project will have three major objectives:

- To enhance understanding, through long-range basic research, of the synthesis, characterization, and properties of advanced materials in support of U.S. energy-related and high-technology industry.
- To provide a next-generation synchrotron light source for U.S. materials science and engineering research.
- To provide advanced facilities for research training of additional graduate students in physical sciences and engineering fields vital to U.S. high-technology industry.

European and Japanese governments are supporting massive research programs to further their aggressive high-technology industrial development. For this country to mount a comparable interdisciplinary attack on the materials and materials-processing problems requires input from basic research efforts with longer time scales and higher risk than can be reasonably undertaken by U.S. industry. The research needed also requires investments in improved apparatus and instrumentation that will strain the present resources of publicly-supported materials laboratories in this country.

The NCAM project will provide the modern tools and facilities required for making possible major advances in energy-related and high-technology industries by improving the scientific understanding of the underlying chemical and physical phenomena that influence both materials and device behavior. A major component of the Center will be the Advanced Light Source (ALS), the first of a new generation of synchrotron light sources.

A further justification for the ALS is its next-generation performance as a light source. With a spectral brilliance of 10_{18} (photon flux per unit of phase-space volume), the ALS will make possible a whole new realm of experimental studies. Transient species on surfaces, excited states of atoms and molecules, and atomic configurations during phase transformations will become accessible to experimental investigation, as will the properties of matter under extreme conditions.

1. Title and location of project: National Center for Advanced Materials, Lawrence Berkeley Laboratory, Berkeley, California and Stanford Linear Accelerator Center, Stanford, California

2. Project No. 84-ER-112

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

The ALS will be a central tool for the three research laboratories that form the other major components of the NCAM:

- The Surface Science and Catalysis Laboratory (SSCL). A laboratory devoted to surface and catalysis studies using the ALS and other state-of-the-art instrumentation techniques.
- The Advanced Materials Synthesis Laboratory (AMSL). A laboratory devoted to interdisciplinary study of the synthesis and characterization of energy-related, high-technology, and strategic materials by use of the ALS and other means.
- The Advanced Device Concepts Laboratory (ADCL). A laboratory devoted to research on the design of high-technology devices utilizing new materials and the design of innovative devices for the characterization of materials-property relationships.

Both the SSCL and the AMSL will build on strong programs that already exist at LBL. The ALS and ADCL elements of NCAM are completely new, but they too build on experience and personnel already at LBL and at the adjacent University of California, Berkeley campus. For FY 1984 and FY 1985 the following programs will be initiated: (SSCL) zeolite characterization, atomic rearrangements on surfaces, and surface properties under extreme conditions; (AMSL) electronic materials synthesis, composite polymer synthesis, alloys, zeolite synthesis, high-pressure crystal structures and phase transformations, and mechanics of materials; (ADCL) x-ray lithography; structural design with brittle materials; three-dimensional solid state devices, high temperature SQUIDS, and photon generation and detection. For FY 1986 and FY 1987, the programs are being defined in collaboration with industry to serve the needs of the nation in regard to advanced materials.

Because of the pressing need to retain high-technology leadership, the proposed project schedule calls for the start of construction in FY 1984, the initial operation of the ALS in FY 1987, and the completion of all conventional and special facilities in FY 1989. Deferral of authorization would extend the time at which research results can be generated and transferred to U.S. industry. A NCAM Advisory Board composed of scientific leaders from industry, universities, and Federal laboratories will advise the LBL director on NCAM scientific program direction.

The existing Stanford Synchrotron Radiation Laboratory has outstanding user facilities that can be dramatically and quickly improved to complement the ALS in the hard X-ray region, thereby providing NCAM researchers with unparalleled photon brightness over an extended portion of the electromagnetic spectrum. Significant intensity improvements now being realized through the use of undulators at SPEAR have been due in large part to collaborative LBL/SSRL efforts, and a continuation of these cooperative activities is a cost-effective way of providing NCAM researchers with additional advanced tools to complement those available at the center.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: National Center for Advanced Materials, Lawrence Berkeley Laboratory, Berkeley, California and Stanford Linear Accelerator Center, Stanford, California

2. Project No. 84-ER-112

10. **Details of Cost Estimate[a/][b/]**

	Item Cost	Total Cost
a. Engineering, design and inspection at approximately 26% of construction costs.........	$	$ 21,100
b. Construction costs..		82,200
(1) Improvements to land, LBL....................................	2,100	
(2) Buildings		
(a) SSCL, LBL 47,500 Gross SF (GSF) @ $150/SF........................	7,300	
(b) AMSL/ADCL, LBL 82,000 GSF @ $200/SF..............................	16,500	
(c) ALS, LBL Building 6 Addition and Building 80 Modification..........	5,500	
(d) South ARC Lab Building, SLAC 13,200 SF @ $121/SF.................	1,600	
(e) SPEAR Insertion Device Shielding and PEP Undulator Beam Line Tunnel, SLAC.....	1,500	
(3) Special Facilities		
(a) ALS, LBL Accelerator Systems Insertion Devices, Photon Beam Lines............	41,100	
(b) SSRL, SLAC SPEAR-Emittance and Aperture Reductions, Insertion Devices, 18° Beam Line,- PEP Undulator Beam Line..........................	5,200	
(4) Utilities, LBL..	1,400	
c. Standard Equipment..		10,600
(1) SSCL, AMSL/ADCL and ALS, LBL..................................	10,500	
(2) SSRL, SLAC...	100	
d. Contingency @ 22% of above costs..................................		25,000
Total..		138,900

[a/] Includes Escalation at 10%/year
[b/] Based on SSCL Building Title II - Design, Remainder of Project Based on Conceptual Design

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: National Center for Advanced Materials, Lawrence Berkeley Laboratory, Berkeley, California and Stanford Linear Accelerator Center, Stanford, California

2. Project No. 84-ER-112

11. Method of Performance

Engineering design of special facilities will be done by laboratory personnel, as will major technical component construction and assembly. Technical components and standard equipment will be procured by fixed-price subcontracts awarded on the basis of competitive bids.

Conventional facilities engineering design for LBL 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. At SSRL design will be accomplished by laboratory and managed by SSRL and SLAC Engineering.

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

	FY 1984	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	Total	
(1) Construction Line item	$ 17,000	$ 30,000	$ 27,300	$ 27,400	$ 28,400	$ 8,800	$138,900	
Total Facility Construction Cost	17,000	30,000	27,300	27,400	28,400	8,800	138,900	(TEC)
(2) Other project funding								
a. Direct R&D operations	4,100	3,000	1,800	3,800	7,000	13,500	33,200	
b. Capital Equipment	500	400	400	700	0	0	2,000	
Total Other Project Funding	4,600	3,400	2,200	4,500	7,000	13,500	35,200	
Total Project Funding	21,600	33,400	29,500	31,900	35,400	22,300	174,100	