U. S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
FY 1977 Budget Estimates

(Dollars in Thousands)

SUMMARY TABLE BY SUBPROGRAM

Basic Energy Sciences

	FY 1975 Actual			FY 1976 Estimate			Transition Quarter Estimate		FY 1977 Estimate	
	B/A	Obs.	B/O	B/A	Obs.	B/O	B/A & Obs.	B/O	B/A & Obs.	B/O
Operating Expenses										
1. Nuclear Science	$ 73,963	$ 73,963	$ 71,842	$ 82,390	$ 82,390	$ 79,120	$ 21,610	$ 20,700	$ 81,200	$ 77,300
2. Materials Sciences	40,926	40,926	39,751	46,275	46,275	43,970	14,200	12,300	51,100	48,700
3. Molecular Sciences	40,640	40,640	39,468	45,315	45,315	44,110	12,910	12,000	50,500	48,000
Total Basic Energy Sciences Program	$155,529	$155,529	$151,061	$173,980	$173,980	$167,200	$ 48,720	$ 45,000	$182,800	$174,000
Plant and Capital Equipment										
Capital Equipment										
1. Nuclear Science	$ 5,800	$ 5,706	$ 4,895	$ 5,675	$ 5,675	$ 5,768	$ 1,300	$ 1,200	$ 5,700	5,300
2. Materials Sciences	3,200	2,964	1,992	3,050	3,050	2,365	800	750	4,600	4,300
3. Molecular Sciences	1,800	2,014	1,454	2,675	2,675	1,915	800	750	2,800	2,300
4. Other Capital Equipment	740	731	1,011	2,100	2,100	1,260	630	660	2,300	2,100
Total Capital Equipment	$ 11,540	$ 11,415	$ 9,352	$ 13,500	$ 13,500	$ 11,308	$ 3,530	$ 3,360	$ 15,400	$ 14,000
Construction Projects	$ 23,690	$ 12,652	$ 4,897	$ 23,050	$ 23,091	$ 9,394	$ 1,315	$ 3,817	$ 28,300	$ 16,388
Total Plant and Capital Equipment	$ 35,230	$ 24,067	$ 14,249	$ 36,550	$ 36,591	$ 20,702	$ 4,845	$ 7,177	$ 43,700	$ 30,388
Basic Energy Sciences Totals										
Operating Expenses	$155,529	$155,529	$151,061	$173,980	$173,980	$167,200	$ 48,720	$ 45,000	$182,800	$174,000
Capital Equipment	11,540	11,415	9,352	13,500	13,500	11,308	3,530	3,360	15,400	14,000
Construction Projects	23,690	12,652	4,897	23,050	23,091	9,394	1,315	3,817	28,300	16,388
TOTAL	$190,759	$179,596	$165,310	$210,530	$210,571	$187,902	$ 53,565	$ 52,177	$226,500	$204,388

U. S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
FY 1977 Budget Estimates
Appropriation - Operating Expenses
(Dollars in thousands, except whole dollars in narrative material)

RESEARCH, DEVELOPMENT AND DEMONSTRATION PROGRAMS

BASIC ENERGY SCIENCES PROGRAM: OPERATING EXPENSES

PROGRAM STATEMENT

Estimate FY 1977	$174,000
Estimate FY 1976	167,200
Increase	$ 6,800

The Basic Energy Sciences program is comprised of three subprograms: Nuclear Sciences; Materials Sciences; and Molecular, Mathematical and Geo-Sciences. The objective is to develop scientific understanding of physical phenomena basic to the energy technologies of all ERDA programs. The work is thus focused on scientific areas judged to have the greatest potential impact on energy applications, although in such research it is not always possible to prejudge how or where the results will be applied. Oftentimes, the results are multidirectional in application. The program is designed to develop new experimental and theoretical insights, new concepts, improved instrumentation and other innovations in the key areas for continued progress in energy research, development and demonstration. The program includes precise experimental determination of data, preparation of specialized materials, and laboratory demonstration of new processes and concepts; where such activities are most effectively carried out as part of a program of fundamental physical research.

The budget presented here is based on a very broad range of technically excellent projects proposed to ERDA by scientists throughout the nation. The request will provide support for the highest quality and highest priority research, resulting in a strong and balanced program related to the full range of energy technologies. It will be a highly selective program in terms of scientific quality, with less than half of the new projects already proposed to ERDA in the areas covered by this program being supported. Many new projects will be started in scientific areas that are basic to fossil, geothermal and solar energy and to energy conservation. This reflects the excellence of the specific proposals in these areas which have already been submitted to ERDA. It also reflects the conclusion of ERDA that a strong need exists to strengthen the basic research supporting applied efforts in these areas in order to establish a balanced program consistent with the Agency's objectives.

The proposed FY 1977 program has been analyzed in terms of those energy technologies to which the increased scientific understanding would be particularly applicable. It is important to reemphasize that the impact of new scientific understanding is typically broad and difficult to specify in advance. Basic energy sciences research provides better insight into how to solve problems; not hardware on the critical path to a demonstration. The new insights typically are useful for more than one applied program. For example, better ideas about superconductivity will not only be helpful in the design of magnets required in fusion programs, but will also contribute to MHD programs in fossil energy and to power transmission programs in conservation. Better calculations on the way in which gases react and how fast they react could be helpful to every energy technology. Most technical areas are of the same multidirectional nature. As shown on Chart I (BE/P-3), we have summed the operating funds for all projects contributing to a given technology, so the sum of the contributions exceeds the total budget request. This type of analysis is particularly useful to us for assuring appropriate program balance.

As reflected in this analysis, the Basic Energy Sciences program has been undergoing a major restructuring and reordering of priorities. The changes began when the Atomic Energy Act was amended to provide specifically for energy research in non-nuclear areas, and have been accelerated strongly since ERDA was established. Research basic to nuclear energy technologies remains important; the FY 1977 operating costs for projects contributing to fission reactor and to nuclear fuel cycle technologies add up to $59,900,000 and $22,500,000, respectively. The sum for fusion technologies is about $60,200,000. For the non-nuclear areas (again with many projects contributing to several areas), the sum is $206,700,000. A "general science" category, totaling $83,300,000, is used for projects such as those dealing with fundamental theories of matter, which are basic to advances in a scientific discipline, rather than basic to a specific energy technology. This includes, for example, medium energy and heavy ion nuclear sciences. Contributions from efforts of this type have in the past often proved to be of especially great importance, and will continue to receive emphasis.

The changes of emphasis in the basic energy sciences program are highlighted in Chart II (BE/P-4), which illustrates the major steps taken to achieve a balanced program and to meet the critical needs for research basic to non-nuclear energy technologies.

A similar analysis can be made where the costs for each research project are associated with a single energy technology to which the project is judged most likely to have the greatest applicability. This results in dollars which can be summed to equal the total budget request. However, such an analysis involves substantially greater uncertainties because it is difficult to assess the relative probabilities of future contributions. The following table shows this type of analysis:

Additive Analysis of Increases in Operating Expenses (Millions)

	Fossil	Solar	Geothermal	Conservation	Fusion	Nuclear Fuel Cycle	Fission	Environmental	General Science	Total
FY 1976	$ 8.8	$ 7.1	$ 4.3	$ 12.0	$ 15.4	$ 10.2	$ 17.3	$ 9.8	$ 82.3	$167.2
FY 1977	12.4	9.1	5.2	13.1	15.3	9.7	16.6	10.5	82.1	174.0
Change	$+ 3.6	$+ 2.0	$+ 0.9	$+ 1.1	$- 0.1	$- 0.5	$- 0.7	$+ 0.7	$- 0.2	$+ 6.8

Chart I

Basic Energy Sciences Program Profile - Operating Expenses

Percentage of Total Program in Areas Basic to a Given Technology

(Many Areas Contribute to Several Technologies)

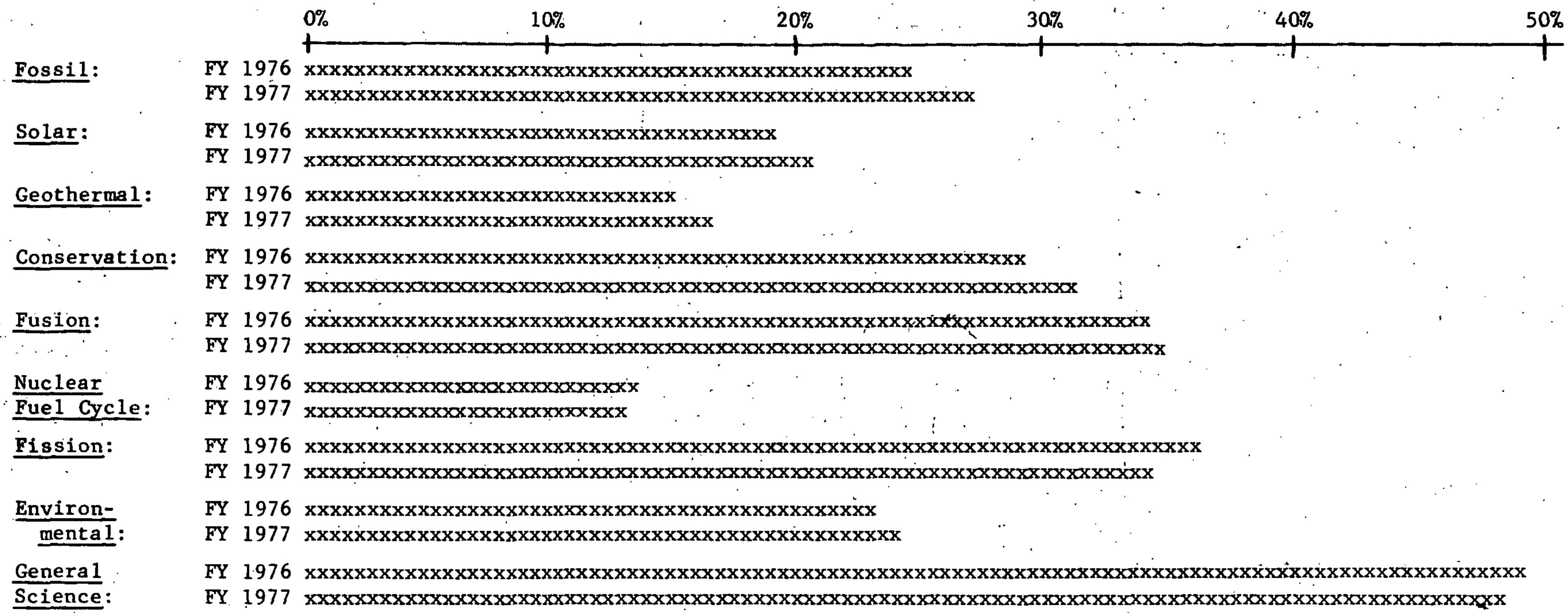

Chart II

Basic Energy Sciences Program Changes

Operating Expenses

Percentage Increase for All Projects in the Areas Basic to a Given Technology

Area	FY 1975 - FY 1976 (-20% -10% 0% 10% 20% 30% 40% 50% 60%)	FY 1976 - FY 1977 (0% 10% 20% 30% 40% 50% 60%)
Fossil	xxxxxxxxxxxxxxxxx	xxxxxxxx
Solar	xxxxxxxxxxxxxxxxx	xxxxx
Geothermal	xxxxxxxxxx	xxxxx
Conservation	xxxxxxxxxxxxxx	xxxxxx
Fusion	xxxxxxxxxxxxxxxxx	xx
Nuclear Fuel Cycle	xxxxxx (below 0%)	x (below 0%)
Fission	xxxxx	x (at 0%)
Environmental	xxxxxxxx	xxx
General Science	xxx	x (at 0%)

(Dollars in thousands, except whole dollars in narrative material)

RESEARCH, DEVELOPMENT AND DEMONSTRATION PROGRAMS

BASIC ENERGY SCIENCES PROGRAM: OPERATING COSTS - continued

SUMMARY OF ESTIMATES BY SUBPROGRAM

Page No.	Subprogram	Actual FY 1975	Estimate FY 1976	Estimate Transition Quarter	Estimate FY 1977
BE/P-5	1. Nuclear Science	$ 71,842	$ 79,120	$ 20,700	$ 77,300
BE/P-15	2. Materials Sciences	39,751	43,970	12,300	48,700
BE/P-23	3. Molecular, Mathematical and Geo-Sciences	39,468	44,110	12,000	48,000
	Total Basic Energy Sciences	$151,061	$167,200	$ 45,000	$174,000

JUSTIFICATION OF SUBPROGRAMS

1. Nuclear Science .... $ 77,300

Nuclear science research covers a broad range of basic studies over a wide energy region, employing a variety of particles as nuclear probes to exploit frontier areas of investigation to develop practical applications of nuclear phenomena and to provide basic information required for the successful development of nuclear energy. Emphasis is given to basic research studies which employ the intense and high resolution beams of nuclear probes which are available from new medium energy facilities (Anderson Meson Physics Facility and Bates Electron Accelerator Facility); and which employ heavy mass beams (heavy-ions) of projectiles extending over a large part of the periodic table as available from the SuperHILAC, Bevalac, and other accelerators. The medium energy and heavy-ion nuclear science areas are recognized as frontier areas of research, and many important new results have been obtained from investigations at these accelerator facilities. Research opportunities for the future abound with the planned further development of these major facilities. The request will permit about 50% utilization of the Bates Linear Accelerator, and about 60% utilization of the other major accelerator facilities.

A number of lower energy accelerator facilities and research reactors are employed to enhance the knowledge obtained from nuclear physics investigations. Special attention is given in the low energy charged particle and neutron research area to nuclear measurements in support of the design of fission and fusion reactor systems. Increasing emphasis will be given to fulfilling nuclear data needs of the fusion power program. These needs are being studied and identified, and they will be met through use of nuclear science facilities. The nuclear research efforts devoted to the actinide (heavy) elements are also stressed. These radioactive elements will be produced in copious quantities in power reactor operation, and as a result of their long half lives and biological toxicity, they pose special problems with regard to their disposal. A number of research studies are being undertaken to provide information of assistance in solving these problems. A number of basic nuclear research accelerator facilities have been closed out in recent years, and the funds have been applied to research of more pertinence

(Dollars in thousands, except whole dollars in narrative material)

RESEARCH, DEVELOPMENT AND DEMONSTRATION PROGRAMS

BASIC ENERGY SCIENCES PROGRAM: OPERATING COSTS - continued

to the applied programs. In particular, the Michigan and Washington University cyclotrons and the Rice and Texas tandem Van de Graaffs are phased out of this subprogram while increased support is given to such facilities as the Oak Ridge Electron Linear Accelerator and the Duke tandem Van de Graaff, which play a major role in programmatic nuclear data measurements. Several new programs in support of nuclear data measurements have also been established. For example, at Livermore studies of hydrogen and helium production induced by 14 MeV neutrons have been initiated in FY 1976 and a program in photofission studies is planned in FY 1977. In FY 1977 no funds will be provided for nuclear sciences research with the Ames reactor or for the University of Maryland cyclotron program.

As the program moves into new research areas and new experimental findings are made, it is important that a comprehensive and complementary theoretical effort be supported. Theoretical studies are carried out in close collaboration with the experimental programs, and they not only lead to suggestions for new experiments, but they also tie together the results of experimental findings. Theory is also employed for developing nuclear models which are used in calculating nuclear properties as needed in the ERDA applied activities.

This subprogram is responsible for providing special research materials for use throughout ERDA research and development programs, for programs of other government agencies, and in special cases for use in international science activities. The naturally occurring chemical elements are separated into isotopic components, and heavy elements beyond those naturally occurring are produced through high flux reactor irradiation and then chemically separated. These special materials are used extensively throughout research programs related to fossil, fission and fusion energy and in environment and safety studies.

Through the diverse experimental and theoretical studies conducted, a new level of understanding of nuclear phenomena and processes is obtained. Applications resulting from basic nuclear research studies have already richly endowed society, and nuclear techniques are employed throughout many scientific disciplines. The programs planned in FY 1977 are expected to produce new results which will further increase our knowledge of nuclear matter, structure and interactions; lead to new practical applications; and contribute to solutions of problems encountered in developing both fission and fusion energy. $50,000 is included under low energy nuclear science for the Lawrence and Fermi awards.

(Dollars in thousands, except whole dollars in narrative material)

RESEARCH, DEVELOPMENT AND DEMONSTRATION PROGRAMS

BASIC ENERGY SCIENCES PROGRAM: OPERATING COSTS - continued

	Actual FY 1975	Estimate FY 1976	Estimate Transition Quarter	Estimate FY 1977
A. Medium Energy Nuclear Science	$ 23,749	$ 28,155	$ 7,360	$ 28,435
B. Heavy Ion Nuclear Science	18,863	20,522	5,470	21,680
C. Low Energy Nuclear Science	18,888	19,152	4,890	16,100
D. Theory and Separated Isotopes	10,342	11,291	2,980	11,085
Total Nuclear Science	$ 71,842	$ 79,120	$ 20,700	$ 77,300

A. Medium Energy Nuclear Science .... $ 28,435

This category includes the nuclear and particle research carried out at accelerator facilities with primary beam energies between the pion production threshold and 6 GeV, and with primary projectile mass not greater than that of the alpha particle. The medium energy accelerators thus defined are the Anderson Meson Physics Facility (LAMPF), the Bates Electron Linear Accelerator Facility, and the Bevatron when it is operated in the light ion acceleration mode. The major support for the latter accelerator, however, is provided under Heavy Ion Nuclear Science since the Bevatron/Bevalac combination is predominately operated for heavy ion acceleration. Support is also provided under this category for nuclear structure and nuclear reaction studies pursued at several high energy accelerators.

The Anderson Meson Physics Facility is the largest and most powerful accelerator facility in the world for medium energy nuclear science research. Its capabilities for performing both basic and applied research studies through simultaneous experiments made possible by acceleration of both positive and negative ion beams at high intensity are unexcelled. Although LAMPF is operated primarily for basic nuclear physics, nuclear chemistry, and particle physics studies; it also offers opportunities for practical application in many other fields including medicine, materials sciences and weapons development. Activities carried out under the sponsorship of other ERDA programs include a radioisotope production program, a pion radiotherapy research program for treatment of cancer, and the Weapons Neutron Research Facility which is expected to begin its research program in FY 1977.

LAMPF completed its first period of extended operation in calendar year 1974, providing an average beam intensity in excess of 10 microamperes at the full design energy of 800 MeV. During that period, beam time was supplied to 65 experiments involving about 400 scientists from 56 institutions. During calendar year 1975, research in the main experimental area was interrupted to permit the necessary preparations to operate at higher intensity levels. Operation above 100 microamperes and up to the full design intensity of 1 milliampere is expected for FY 1977. Two major additional experimental facilities - the Energetic Pion Channel Spectrometer (EPICS) and the High Resolution Spectrometer (HRS)-are scheduled for full operation in FY 1977. A polarized ion source is also being established, which will give a new dimension to the experimental research program.

Substantial progress in the research program was made prior to the shutdown. Nuclear charge distributions have been studied through measurement of muonic x-rays using the Stopped Muon Channel. Preparations for very high resolution muonic x-ray experiments are well advanced to coincide with high intensity operation. A number of radioactivity measurements of pion and proton produced spallation products have been conducted to obtain nuclear structure and reaction mechanism information, successful measurements have been made of pion-nucleus total cross sections at low energy, initial data have been taken on three neutrino experiments, the muonium hyperfine measurement effort continues with improved experimental accuracy, and preliminary studies for inelastic pion scattering at low energies have commenced.

The increase requested for medium energy nuclear science is $280,000, to an FY 1977 level of $28,435,000. No increase is requested for the operation of LAMPF. LAMPF operation is planned at extremely high intensity levels (approaching 1 milliampere average current) with full use of new experimental capabilities, including the polarized ion source, polarized targets, and the two large spectrometer systems. Utilization is estimated to be about 60% in FY 1977. Since LAMPF is a national facility, much of the research is conducted by user groups from other major federal laboratories and from universities. The total FY 1977 funding for such user groups is planned at about $4,300,000.

The Bates Electron Linear Accelerator Facility holds a unique position in the medium energy nuclear science area, because it is the only electron accelerator in the United States operating in the several hundred MeV energy region. The facility represents a major advance in electron accelerator technology, resulting in a high duty factor and precise beam energy resolution. In FY 1975, the facility achieved spectacular success in its early operation, providing electron scattering results of unprecedented quality made possible by a high resolution spectrometer system which is matched to the capabilities of the accelerator. These new results will provide unique insights in nuclear structure physics and in electromagnetic properties of nuclei. The major emphasis of the program currently is limited to electron scattering studies, and development of a broad program of nuclear research depends upon construction of a second experimental area, which is requested in FY 1977. The results obtainable from electromagnetic probing of nuclei at the Bates Linac are essential for complete interpretation of many research results obtained at LAMPF, which uses strongly interacting probes and mu mesic x-ray techniques. Thus the two facilities are complementary for many research investigations in the medium energy area.

The increase requested for the Bates Linac is $300,000, to an FY 1977 level of $3,300,000. Twenty-two proposals have already been submitted for experiments in electron scattering and photoreactions from 60 scientists in 19 institutions. The requested funding will permit a utilization level of about 50%, at average current up to 150 microamperes and energies up to 400 MeV. In FY 1977, $150,000 is planned for support of Bates Linac user groups, who are enthusiastic about the research potential of this facility, especially in accommodating a broader program.

Medium energy nuclear research is also carried out at the Bevatron where a new stopped kaon channel has been brought into operation, which will permit extension of the kaonic x-rays studies which were pioneered at Berkeley. New studies of the level structure of hypernuclei are also planned with the kaon beam, which should contribute to a knowledge of nuclear properties and the hyperon-nucleon interaction. Other research includes spallation studies and fragment production from heavy element targets. In FY 1977, $1,000,000 is provided for Berkeley under medium energy nuclear science operations, the same as the FY 1976 level. Operating funds for the Bevatron are also provided under heavy ion nuclear science and by the Division of Biomedical and Environmental Research.

A new and potentially far reaching program in the study of hypernuclear physics is being established at the Brookhaven Alternating Gradient Synchrotron (AGS), where a new spectrometer will be available for measurements in mid-FY 1977. Nuclear reaction studies for complex nuclei bombarded by high energy projectiles, primarily at the AGS, will be continued. Nuclear reaction mechanisms are also studied using the Zero Gradient Synchrotron, and on-line counter experiments are planned at Fermi National Accelerator Laboratory (FERMILAB), for investigation of specific relativistic effects on reaction mechanisms.

The off-site program, for which an increase of $209,000 is requested, provides principally for the support of LAMPF and Bates Linac user groups, but also includes support of nuclear chemistry groups working at high energy accelerator facilities. Decreases totaling $229,000 will be allocated to several contractors.

B. Heavy Ion Nuclear Science .... $ 21,680

Nuclear research using accelerated heavy nuclides (mass greater than that of the alpha particle) has developed into a broad area of study that is receiving increasing emphasis in this country and abroad, and it has become the primary interest at many major nuclear research laboratories. The heavy ion projectiles open up a vast new area of study, because they can be any of the more than 300 stable nuclei known, as well as some of the longer lived radioactive species. Heavy ions as nuclear probes bring new properties (high electric charge, large numbers of nucleons, high angular momentum) into use for the study of nuclear reactions and nuclear structure. Examples of the nuclear properties now under study by heavy ion techniques include nuclear shapes, excitation and de-excitation mechanisms, limits of angular momentum and other aspects of nuclear structure as well as a study of nuclear reaction mechanisms, the forces between nuclei, nuclear viscosity, and the interchange of energy and mass between target and projectile. An example of this latter item is the new phenomena called "strongly damped collisions" or "quasi-fission".

Heavy ion research is presently the predominant focus at several tandem Van de Graaff accelerators and cyclotrons. These accelerators, however, have capabilities for exploring heavy ion nuclear reactions only in the lower mass region of the Periodic Table. Through improvements in heavy ion sources and increased voltage capabilities for several of the tandems, a modest gain has been made in extending the mass region accessible for study. A major milestone will be achieved when the 25 MV tandem electrostatic accelerator facility under construction at the Oak Ridge National Laboratory becomes operational in 1979. This facility will provide precision beams for extending research through the light mass part of the Periodic Table, and when the tandem is operated as an injector into the existing heavy ion cyclotron, the facility will have unsurpassed capabilities for precision nuclear studies through the middle mass region of the Periodic Table.

An increase of $1,158,000 is requested for heavy ion nuclear science, which will provide an FY 1977 level of $21,680,000. In FY 1977 an increase of $299,000 is required for the research and development effort associated with the 25 MV tandem construction project, and an increase of $195,000 is required for increased electric power costs at the Oak Ridge National Laboratory heavy ion cyclotron.

The SuperHILAC at Berkeley continues to be the most powerful low energy (up to 8.5 MeV/nuclear mass unit) heavy ion accelerator operating in the United States, but its capabilities fall short of those of new foreign heavy ion facilities being established. The SuperHILAC will accelerate heavy ions into the heavy mass region of the Periodic Table; but it cannot provide full coverage up to uranium. An increase of $85,000 is required for operation of the SuperHILAC at an FY 1977 level of $3,085,000 This will permit a utilization level of about 60% The SuperHILAC is operated as a national facility and serves an extensive user group community. The current upgrading of this facility should result in a higher degree of reliability to better serve the user community.

The Bevalac at Berkeley is unique as a high energy heavy ion accelerator, attaining energies as high as several GeV per nucleon and as low as several hundred MeV per nucleon. Success has been achieved at the Bevalac in accelerating ions as massive as argon, and the possibility of Bevalac acceleration of krypton beams is being explored. To achieve the acceleration of uranium through the Bevalac would, however, require a new injector at the SuperHILAC and an improved vacuum system for the Bevatron. An outstanding achievement at Berkeley has been the successful accomplishment of computer controlled beam time sharing between the SuperHILAC and the Bevalac; that is, the simultaneous acceleration of two different beams to two different areas in the SuperHILAC, or to the SuperHILAC and the Bevalac. An accelerated single beam can also be shared between the SuperHILAC and Bevalac. Investigations of nuclear structure by studying fragmentation of nuclei in high energy collisions are underway at the Bevalac, and of particular interest is the possibility of exploring the properties of nuclear matter at unusual densities. The Bevatron/Bevalac operation is expected to receive funding of $2,000,000 in FY 1977 from the Division of Biomedical and Environmental Research, $1,000,000 under medium energy nuclear science, and $3,000,000 under this category. This is a total of $6,000,000, which is the same as the FY 1976 level. The overall accelerator utilization expected at an FY 1977 level of about 60%. Berkeley is one of the world's major centers of heavy ion research.

An important heavy ion project is continuing at Argonne in which a small cryogenic linac is being developed as a prototype heavy ion booster--the first of its kind--for tandem Van de Graaff accelerators. This development will represent an important contribution to heavy ion accelerator technology and will permit a significant extension of heavy ion research at Argonne. An increase of $198,000 is requested to provide for the accelerator development effort at Argonne. The double tandem accelerator at Brookhaven will continue to be the world's highest energy electrostatic accelerator system in operation, and it will be devoted almost exclusively to heavy ion research. It is operating as a regional facility, with approximately half the beam time made available to university user groups. The research program covers a wide range of investigations, including studies of heavy ion direct reaction mechanisms, production of "exotic" nuclei far from the line of nuclear stability, examination of heavy ion induced fission and fusion processes, and x-ray production from heavy ions. An increase of $110,000 at the University of Washington reflects a shift in emphasis toward heavy ion research. The increase requested under the off-site program is $190,000, primarily to provide for the support of heavy ion research user groups. As is the case for the medium energy nuclear research program, a strong user group mode is being developed for heavy ion research. Minor increases for other contractors total $81,000.

C. Low Energy Nuclear Science .... $ 16,100

The low energy nuclear science category encompasses experimental studies at national laboratory and university based accelerator and reactor facilities, including studies of radioactive decay. Using beams of nuclear projectiles with a mass not exceeding that of the alpha particle, and energy below the pion production threshold, scientists study the interaction of nuclear probes with target nuclei. Emphasis is given to elucidating the mechanisms by which these beams interact with nuclei and to extracting nuclear structure information. Major objectives under this category include: 1) development of instrumentation and techniques for measurements of nuclear properties and for analysis of nuclear data; 2) compilation and evaluation of nuclear data of use to the applied programs of ERDA as well as to the basic research community; and 3) development of an understanding of the systematic variation of nuclear properties as a function of proton and neutron number and an understanding of reaction mechanisms including the fundamental nucleon-nucleon interaction. Under this category, support is provided for the Nuclear Data Project, the Table of Isotopes project, and the National Neutron Cross Section Center (NNCSC). While the provision of a broad underpinning of nuclear data and an understanding of the systematics of nuclear structure will remain a major objective of the program in FY 1977, specific priority will be directed toward acquisition of a nuclear data base needed to evaluate the concept of actinide burnup as a means of nuclear reactor waste disposal and to acquisition of a nuclear data base for the fusion reactor program.

Much of our present knowledge of nuclei and their interactions has been built up from low energy charged particle research studies. It is upon this base that an extended knowledge of nuclei is being developed with medium energy and heavy ion probes. It is important that a high level of competence and expertise be maintained in this area. Further, many of the applied data needs lie directly within the realm of the studies supported here. In particular, there remains a continuing requirement within the fission and fusion energy programs for nuclear spectroscopic information and for nuclear decay information, including half-lives of fission fragments for nuclear waste disposal applications and reactor safety.

An overall decrease of $2,412,000 is planned for charged particle research. The decrease reflects a shift of emphasis at university and laboratory accelerator facilities to heavy ion research; close out of nuclear research at the University of Maryland cyclotron and the Washington University (St. Louis) cyclotron; and close out of several smaller research efforts at universities. Fusion energy related research at Los Alamos will continue at the FY 1976 level.

Within neutron and fission research, emphasis is given to the study of the interaction of neutrons with nuclei and to the nuclear fission process. In FY 1977, it is planned to establish a measurement effort at the Oak Ridge Electron Linear Accelerator (ORELA) to determine neutron capture and neutron induced fission cross sections for actinide nuclides. These studies will contribute to a data base needed to evaluate the concept of using actinide burnup as a means of reducing long-lived nuclear waste to short-lived nuclear waste. At ORELA, priority will also be assigned to acquisition of data for neutron induced reactions on structural materials likely to be used in working fusion power reactors and in projected controlled thermonuclear research experiments. In addition to ORELA based work, controlled thermonuclear research related measurements will be carried out at Argonne, Livermore, and Duke University. Neutron standards efforts will continue at ORELA and other locations. The FY 1977 program also envisions continued efforts in the determination of delayed neutron energy spectra following fission events and energy distribution, mass distribution, and decay properties of fission fragments. The basic research component of the neutron cross section measurement program gives priority to study of the resonance parameters of nuclear systems, to study of statistical properties of nuclei, and to study of mechanisms by which neutrons interact with nuclei.

An overall decrease of $845,000 is planned for neutron and fission research. Within this total, an increase of $299,000 is planned at ORELA for initiation of neutron cross-section measurements on actinide targets (evaluation of actinide burn-up as a waste disposal technique), for augmentation of fusion-related neutron cross-section measurement efforts, and for anticipated increased cost of linac operation. A $10,000 increase at Livermore is planned for fusion-related measurements. Within a decrease of $15,000 for the off-site program, fusion reactor associated nuclear data measurements will be increased at the expense of fission reactor related work. Within the off-site program and at Savannah River, $500,000 is allocated for the University Reactor Fuel Assistance Program and the University Reactor Sharing Program. A $600,000 decrease at Ames and a $344,000 decrease at Argonne reflect close-out of nuclear research at the Ames Laboratory Research Reactor and the Argonne CP-5 reactor. Decreases for other contractors total $195,000.

Heavy element research is concerned with studies of the basic chemical and physical properties of the actinide (heavy) elements and their chemical compounds. The studies here transcend the determination of nuclear properties. They include measurement of atomic properties, magnetic properties, thermochemical properties, chemical reactivity, etc. The actinide elements are of primary importance to ERDA's nuclear fission energy development program, nuclear weapons program, biomedical and environmental research, waste management, and safeguards and security. The research is dedicated to gaining a thorough understanding of all aspects of these elements, and is of substantial benefit to: the further development of reactor fuel reprocessing and waste management systems; an understanding of the behavior of these elements under biological and environmental conditions; the design and development of new fuel forms for advanced design fission power reactors; and the further development of practical applications for the transplutonium elements. An increase of $205,000 to an FY 1977 level of $2,020,000 is requested for heavy element research. At Berkeley, there is being implemented a major program expansion for an in-depth study of the atomic spectroscopic properties and the organo-metallic chemistry of the actinide elements. This will include investigations of the spectroscopic properties of certain actinide elements in glasses and crystals that may be of potential laser interest, and of gaseous actinide compounds. An increase of $100,000 is required for this program. At Argonne an increase of $65,000 is required for program expansion in a number of areas, including chemistry of the actinides in intensely ionized solutions; chemistry of actinide elements in fuels under reactor operation conditions; and a study of the rates of chemical reactions involving actinides. At Oak Ridge an increase of $40,000 is requested for the study of the chemical behavior of the heaviest elements number 105 and 106; for the study of thermochemical properties of the heavy elements and their compounds by solution calorimetry; and for new studies of the changes in the nature of the chemical bonding of actinides as a function of changes in pressure and temperature.

D. Theory and Separated Isotopes .... $ 11,085

Activities under nuclear theory interact with experimental research over the entire nuclear science subprogram. There is a strong coupling both through theoretical guidance in planning of experimental efforts and in the theoretical analysis of experimental results. An important objective is to establish a unified framework for understanding nuclear structure and nuclear reaction mechanisms. Current priority is given to meson induced nuclear reactions, to properties of nuclei off the line of stability, to collective nuclear excitations including fission, to electromagnetic properties of nuclear states, to mechanisms by which heavy ion - heavy ion collisions take place, and to the details of nuclear structure revealed by newly available intermediate energy and heavy ion nuclear data.

The heavy ion studies are intimately related to nuclear fission because, in many respects, fission is the inverse reaction to the heavy ion - heavy ion fusion reaction. There is great current interest in understanding the means by which large excitation energy is transferred to target nuclei in energetic heavy ion - heavy ion nuclear reactions and in understanding the highly collective motions undergone in such collisions. Theoretical calculations on high energy heavy ion collisions have speculated on the possibility of creation of regions of very high density in the nuclear matter and on the possibility of producing nuclear shock waves. Recent work has indicated that many macroscopic phenomena of heavy ion - heavy ion collisions can be understood in terms analogous to classical frictional forces. Also, there is now good theoretical evidence that new quantum electrodynamic effects will appear for nuclei with atomic numbers in the range 130 to 184 (systems whose existence will be brief but observable in heavy ion - heavy ion collisions).

In the medium energy theory area, attention is being given to the mechanisms by which pions traverse and interact with nuclear matter and the nature of the nuclear states excited in pion-nucleus collisions. This theoretical work is largely stimulated by the high quality of data emerging from the Anderson Meson Physics Facility. Attention is also given to studies of nuclear charge distribution by analysis of muonic x-ray energy data with emphasis on understanding nuclear polarization effects and on models of electric charge distribution within nuclei. The intermediate energy studies include detailed examination of fundamental properties of the pi meson and the mu meson as well as production processes by which mesons are created in energetic collisions. High precision electron scattering data from Bates has stimulated theoretical interest in electromagnetic properties of individual nuclear states.

In terms of the more classical theories, emphasis is now being given to structure of nuclei at high angular momentum and high excitation energy. In particular, there is great current interest in the structure and collective deformation of high excitation states of intermediate mass nuclei and in the dynamics of the fission process.

Because of its importance to overall nuclear science research efforts, an increase of $202,000 is requested for nuclear theory. Of this amount, $50,000 is required at Los Alamos, where a quite successful effort is being made to establish an intermediate energy theory group whose activites interact quite strongly with both in-house and university-based user group research at LAMPF. A $100,000 increase is required at Berkeley to complement growth of the high priority heavy ion experimental program, and a $40,000 increase is planned for the heavy nucleus theory effort established at Livermore in FY 1976. A $40,000 decrease at Ames reflects close out of nuclear theory research at that laboratory. Other minor increases total $52,000, primarily for university theory efforts.

The electromagnetic isotope separations effort supports calutron operations at the Oak Ridge National Laboratory and provides a wide variety of separated and purified isotopes of various enrichments and sample forms. In certain cases, unwanted isotopes have been reduced to the few-parts-per-billion range. These samples are used throughout physical research programs on a loan basis for non-destructive measurements. Separated isotopes are also sold for use in research programs where they will be activiated, contaminated or consumed. A major end use of separated isotopes in the sales program is for targets for the production of special purpose radioisotopes by the medical and industrial communities. A loan pool of samples of isotopes is maintained, which are of special importance as targets for neutron cross section measurements in fulfilling programmatic nuclear data requirements for the development of both fission and fusion energy. A portion of the calutron facility is operated for the separation of the heavy elements (e.g., uranium and plutonium), which are used in research studies of very special importance to nuclear fission energy. A decrease of $300,000 is planned for the operation of the electromagnetic separation facility.

The special isotope preparation detail provides for the funding of the High Flux Isotope Reactor (HFIR) and the Transuranium Processing Plant (TRU) at the Oak Ridge National Laboratory. This combined facility is charged with the production, separation and purification, and distribution of the transplutonium elements needed by the investigators pursuing research in this increasingly important area. The HFIR provides the highest neutron flux for research available in the country, and in addition to isotope production provides research sample irradiation and neutron beam facilities for a number of users in ERDA programs on a cost reimbursement basis. In addition to processing the heavy isotope producing targets from HFIR, TRU provides a service of special sample preparation and processing for a number of heavy element investigators. Also supported by this detail is the research and development required in the Special Target Preparation program. A decrease of $108,000 is scheduled for this detail.

2. Materials Sciences .... $ 48,700

The materials sciences subprogram is directed toward the acquisition of an expanding base of knowledge of materials properties and behavior in increasingly demanding environments important to all energy systems. Emphasis is placed in areas where problems are known to exist or are anticipated, and where significant improvements in performances must depend on materials selection (and engineering design) based on improved understanding of the underlying mechanisms. The program includes materials research, broad in character, from which new solutions to existing problems and new materials will emerge, insight to identify future materials troublespots will be provided, and working models to deal with unpredicted problems or phenomena when encountered will be formulated. An underlying long-term benefit of the program is the elimination of the dependency of the nation on scarce resources, e.g., chromium.

Improved or new materials and expanded knowledge of the properties of conventional materials are required in all aspects of energy generation, conversion, transmission, storage, utilization and conservation. All too often systems designers assume that materials with properties to meet requirements are available; discover that they are not; and then must make substitutions in order to demonstrate feasibility of the concept. Developments in materials technology then become the pace setting factor in the maturing, or in some cases, the success of the concept.

The full range of ERDA's activities will require materials of almost every conceivable type to operate in regimes from the mundane to the harshest imaginable. It should be recognized that: it takes approximately ten years for a new material to gain commercial acceptance; most energy technologies have severe materials problems; new materials problems will emerge in these technologies; and new energy concepts will evolve in the years ahead with materials requirements not currently definable. Therefore, a strong, broad-based program of fundamental materials science is essential to assist the on-going developmental programs and to provide the base for future programs.

In the materials sciences subprogram, primarily the disciplines of metallurgy, chemistry, engineering, ceramics, and solid state physics are brought to bear in an interdisciplinary manner on problems common to several systems. In the past the focus of the subprogram has been nuclear oriented. However, a cross cut shows that a substantial fraction of the research supported is multidirectional, and is therefore also related to problem areas in nonnuclear systems. To reflect the added scope and increased responsibilities placed upon the subprogram by the establishment of ERDA, the spectrum of research is changing by the initiation of support of research in new areas not previously supported, and by shifting emphasis to areas having increased importance because of their relationship to nonnuclear technologies. The shifting of emphasis will be accomplished to a great extent by phasing out other important but lower priority research. In particular, the requested increase will be devoted to areas related to solar energy, geothermal energy, fossil energy, and energy conservation. The new programs are being planned in coordination and cooperation with both headquarters and field staff. To facilitate this coordinated effort, an ERDA Materials Coordinating Committee has been established. At the same time, fission and fusion options continue to be of high priority, and critical materials problems associated with them continue to be of importance and require due attention.

BASIC ENERGY SCIENCES PROGRAM: OPERATING COSTS - continued

In FY 1977, a balanced research effort in support of all ERDA activities is proposed, as shown in the following tables. The first table takes into account the multidirectional nature of the research, so that the sum of the areas supported is greater than the FY 1977 request. The second table shows each program associated with that single area to which it is most relevant, so that the sum of the areas equals the total FY 1977 request. Achieving the levels indicated will require reorienting support from nuclear fission related research into other areas in order to accommodate the expanded programmatic responsibilities.

FY 1977 Operating Expenses
by Area of Support
(Non-Additive, Dollars in Millions)

	Fossil	Solar	Geothermal	Conservation	Fusion	Nuclear Fuel Cycle	Fission	Environment	General Science
FY 1977	$29.5	$21.0	$19.6	$36.5	$42.0	$ 2.5	$44.5	$13.9	$ 6.5

FY 1977 Operating Expenses
by Area of Support
(Additive, Dollars in Millions)

	Fossil	Solar	Geothermal	Conservation	Fusion	Nuclear Fuel Cycle	Fission	Environment	General Science	FY 1977 Total
FY 1977	$ 6.5	$ 4.5	$ 2.9	$ 8.0	$ 8.0	$ 1.0	$ 9.5	$ 1.8	$ 6.5	$48.7

Typical areas of fundamental materials research to be emphasized include: high temperature materials research because of its importance to combustion, MHD, coal conversion, heat extraction from magmas, and fusion and turbine application; research on influence of gases on the properties of materials because of its importance to coal conversion technologies, fission and fusion, technologies involving hydrogen, and high temperature systems in general; corrosion research because of its importance to geothermal technologies, coal conversion and combustion, solar (ocean thermal and solar thermal), and steam turbines; erosion and wear because of their importance to geothermal and fossil technologies, high temperature conversion systems (turbines and MHD) and solar (collectors and wind systems); research on properties of surfaces because of its importance to solar (e.g. photovoltaic and collectors), catalysis, heat transfer and film formation, corrosion and the exchange of constituents between contacting media, and fuel cells; the interaction of electromagnetic and particulate radiation with matter which is important to solar, fission and fusion technologies; and the very broad area of mechanical properties, including creep, fatigue, strength, fracture, toughness and ductility which is important to all energy technologies. With regard to the latter, if it were possible to predict the mechanical behavior of structural components as a function of environment (stress, corrosion, radiation, etc.), time, temperature and pressure; then avoidance of catastrophic failure would be possible and the design life of systems or subsystems could be accurately predicted and meaningful design changes implemented.

Most of this research is conducted at the multiprogram national laboratories in close proximity to the applied programs. In this manner, the transference of new information and techniques into technology is facilitated and at the same time the needs of the applied programs are brought to the attention of the basic research community. Also, at the national laboratories, specialized and unique facilities are available to attack highly complex materials problems and problems involving unusual or extreme experimental conditions. In implementing the program, new research will be initiated at the Sandia Laboratories, Aerojet Nuclear Corporation, the Lawrence Livermore Laboratory and other laboratories, both private and government, to exploit special capabilities not available elsewhere in the program. Special attention will be given to research capabilities residing in universities. The support of research in universities is justified on the basis of research opportunities at these institutions. Recognition is given to the fact that highly trained manpower in the critical area of materials science will also result whose skills will be oriented toward energy technologies.

An increase of $4,730,000 to an FY 1977 level of $48,700,000 is requested to maintain an adequate level of materials sciences research. This will maintain the same level of effort as in FY 1976, considering inflation and increased reactor costs. New areas of research will be initiated as rapidly as possible. The major areas for increased emphasis include: gases in metals, solar photothermal and photovoltaic materials, materials for fossil energy, laser light interactions, ion implantation, hard materials for drilling, corrosion and erosion, stress corrosion cracking, high temperature materials, materials for geothermal, solid electrolytes, surface research, engineering materials research, theory, molten salt and liquid electrolyte research.

The materials sciences subprogram is divided into three major categories: (a) metallurgy and ceramics, (b) solid state physics, and (c) materials chemistry. These reflect both the technical content and the primary discipline employed, as shown below:

	Actual FY 1975	Estimate FY 1976	Estimate Transition Quarter	Estimate FY 1977
A. Metallurgy and Ceramics	$ 17,223	$ 19,060	$ 5,290	$ 21,100
B. Solid State Physics	16,254	18,020	4,890	19,970
C. Materials Chemistry	6,274	6,890	2,120	7,630
Total Materials Sciences	$ 39,751	$ 43,970	$ 12,300	$ 48,700

A. Metallurgy and Ceramics .... $ 21,100

The objective of the metallurgy and ceramics category is to understand the relationship between materials properties and structure. Under this category, research is conducted on topics and phenomena closely related to areas of interest in the applied energy programs. Important topics such as fracture, plastic flow, superconductivity, corrosion, radiation effects, transport phenomena and others are all dependent on structure. As our understanding of the relationship between structure and properties becomes more complete we will be able to design materials to meet engineering requirements - a task which is not possible at the present time. We also will be able to more accurately predict the behavior of materials and changes in materials properties over time and in different environments. The subjects chosen for the study are those deemed to have the greatest payoff for energy systems. For example, the whole area of high temperature materials, ceramics and refractory metal alloys is one receiving emphasis because of the increased efficiency resulting when energy plants operate at higher temperatures.

An increase of $2,040,000 is requested for the metallurgy and ceramics category. New research initiated within this request will be in the non-nuclear areas. It should be pointed out that the new fossil energy systems (coal conversion plants) will require the rapid initiation of research in materials topics such as sulfidation mechanisms, fracture, erosion and stress corrosion cracking if a sufficient base is to be established for successful operation of these plants. Similarly, other new energy technologies (fuel cells, solar energy conversion, magnetohydrodynamics (MHD), hydrogen systems, geothermal energy and superconducting systems) all have severe limitations placed on them primarily by the materials requirements.

In order to be able to relate the necessary properties and phenomena to their underlying fundamental structure for all these technologies, a greatly increased level of support is imperative. This request will permit modest starts in these areas. A new effort within the metallurgy and ceramics category will be the engineering materials area. This will focus on the more complex materials and phenomena generally associated with engineering systems. Examples of the type of research to be undertaken include: friction, wear, erosion, corrosion, mechanical equation of state, welding and joining, non-destructive evaluation and new methods for materials preparation. This area has not been emphasized in the past. It will provide the necessary transition between many of the new developmental energy sources and conversion schemes and the materials research program. Other new areas of thrust include: thermal properties for solar photothermal devices, properties and behavior of solid state electrolytes, effects of gases in metals, growth and properties of solar photovoltaic materials, catalysis and composites.

The metallurgy and ceramics research supported here is closely coupled to the applied energy programs, which are often supported within the same ERDA laboratory division where both applied and basic research are conducted. This close coupling benefits the nation's energy programs, as demonstrated by the large number of both scientific and technological accomplishments during the past year. One example is the fabrication of new ceramic-metal composites which have shown excellent structural stability in corrosive and high temperature environments and thus are potential materials for MHD electrodes. Another example is the culmination of research directing the way toward a swelling resistant stainless steel which is expected to save the LMFBR program several billions of dollars over the years ahead. Another example is the methods and technology for producing multifilamentary superconducting wire which will be essential for superconducting machinery, power transmission and fusion reactors.

The structure of materials detail encompasses research conducted to increase our understanding of atomic, electronic and macroscopic defect structure of materials. An increase of $740,000 is requested. Of special importance will be new programs on erosion mechanisms of interest for coal conversion and geothermal systems, hot corrosion studies, and the structure of surfaces related to catalysis. High voltage electron microscopy will be emphasized for studies of ceramics and composite materials. Structural studies of potential MHD electrode and insulator materials are to be emphasized. Materials conservation studies will be initiated for scarce materials, for example, alloy substitutes for chromium.

The mechanical properties detail requires special attention, especially in view of the need to accurately predict failure mechanisms in new energy systems. Under this detail, research is conducted to increase our understanding of elastic and plastic phenomena such as creep, internal friction, yield strength, elastic constants, fracture and dislocation phenomena. An increase of $580,000 is requested. Design methods for using mechanical equation of state phenomena and new alloy procedures will be investigated. The area of hydrogen embrittlement and stress corrosion cracking is to be expanded greatly in view of the importance of these phenomena in hydrogen storage systems and fossil energy conversion plants. Strength of ceramic materials and composites will be emphasized. The principal aim will be to examine problem areas associated with MHD systems. Mechanical properties measurements and phenomena such as fatigue and embrittlement in various gaseous atmospheres will be pursued at extremely high temperatures.

Physical properties research during FY 1977 will stress new studies of alloy properties useful for catalysis, superconducting materials properties such as alternating current losses, and photovoltaic and photothermal properties of materials of interest for solar energy. A new and exciting research program on the properties of ion implanted materials will be initiated. Other areas of emphasis will be thermal conductivity and mass transport in steep electrical and thermal gradients. Diffusion of ionic species in candidate materials for solid state electrolytes will be investigated. An increase of $620,000 is requested for these important research areas.

Under radiation effects, research is conducted to understand the effects of all types of radiation on the properties, and changes in properties, of metals and ceramics. In view of the need to accelerate research in the non-nuclear area, radiation effects research is not being stressed as much as the other areas under the metallurgy and ceramics category. An increase of $100,000 is requested to maintain the research on the outstanding problems in radiation damage, which are important for both fission and fusion reactor concepts. Emphasis will be on irradiation induced creep studies, radiation embrittlement, and swelling at high fluences under high energy neutron bombardment. Research will stress the use of ion irradiation facilities, the new high voltage electron microscopes at the Oak Ridge National Laboratory and Argonne National Laboratory, and new techniques such as positron annihilation to study irradiation induced defects.

B. Solid State Physics .... $ 19,970

Under the solid state physics category, a broad-based experimental and theoretical effort is directed toward fundamental understanding of matter in the condensed state, and thereby contributes extensively to formulation of basic materials processes and properties related to conservation, solar energy, fossil energy, and fission and fusion systems. Research under this category continually advances through the discovery and perfection of new diagnostic tools for exploring material behavior. Some of these include laser interactions, ternary electron-beam material preparation, quasielastic neutron scattering of fluxoid configurations in superconductors, inelastic neutron probes of atom-sized defects in materials, field-atom analysis of surface properties, and rapid computer coupling of linked experimental-theoretical material investigations. The condensed state of matter not only includes the materials we commonly utilize, but also those materials of the future, which through discovery and exploitation will undoubtedly assist in alleviating the energy and environmental problems that face the nation.

Accomplishments during the past year under this category include the following: (a) Ternary electron beam deposition of superconducting materials has resulted in the rapid, controlled preparation of high field materials. It is anticipated that this improved fabrication method will lead to the discovery of higher critical temperature superconductors of importance to power transmission and conservation. (b) Two advances in neutron spectrometry have resulted in major experimental accomplishments. In one case the direct observation of fluxoids with spacings as small as 1,000 angstroms has been obtained in superconducting niobium (an angstrom is one hundred millionth of a centimeter). These results should lead to better control of magnetic quenching effects in superconductors. The second case is the experimental confirmation of an oscillating two-atom dumbell predicted by theory for an early defect produced by neutron bombardment in metals. The experimental results are not only important to fission and fusion reactor materials understanding, but also have greatly advanced the art of material analysis with the advent of the highest resolution neutron probes in the world. (c) Ferroelectric investigation of lithium niobate revealed that the material degraded in output upon neutron irradiation to 2×10^{19} neutrons per square centimeter. This result sets the lifetime use of this material as an acoustical monitor in fission reactor safety application. (d) Thin film direct current SQUIDS (superconducting devices for measuring very small magnetic fields and voltages) have been successfully fabricated and field tested. The devices have an important potential use as sensors in earthquake and shock wave predictions far in advance of major calamities. (e) High efficiency solar photovoltaic material was prepared from silicon single crystals doped with randomly dispersed phosphorous carriers. The random dispersion was achieved through neutron induced transmutation of silicon to stable phosphorous, a new technique that may prove extremely valuable in large scale production of efficient photovoltaic silicon for use in solar conversion.

A major thrust of this category is directed toward fulfilling major advances in solid state physics that are related to the new ERDA efforts in energy conservation, transmission and storage, solar energy, MHD, fossil energy, and advanced energy concepts. To stimulate these efforts, special programs will be strengthened at ERDA laboratories in order to exploit the unique capabilities that exist within those institutions. A central theme of these efforts in superconductivity and cryogenic transmission, hydrides and hydrogen, MHD materials, surfaces and catalysis, and solar materials, is aimed at greatly improving energy conservation through more efficient and long-lived material acquisition. The understanding of the fundamental properties of materials is urgently required if accelerated progress is to be made in advancing all energy generation and conservation systems. The solid state physics category plays a major role in this effort through support of frontier experimental and theoretical techniques in materials research. An increase of $1,950,000 is requested, to an FY 1977 level of $19,970,000.

The neutron scattering detail supports experimental probing of the structural magnetic, superconducting, vibrational, and defect properties of solids. As an analytical tool it is unique in most of these efforts, particularly in hydrogen detection and tracking in solids, and in superconductive behavior prediction. Nearly all of the nation's effort in this important field is carried out in the research reactors at the ERDA laboratories, where increasing fuel costs have severely hampered the support of these facilities. In order to maintain a viable program of research using recent advances in neutron probing of superconductors, high temperature materials, material defects, and hydrogen motion in solids, an increase of $445,000 is requested.

The very broad experimental research detail includes all of those fundamental investigations of an experimental nature on metals, alloys, insulators, compounds, semiconductors, and liquids. Major attention will be given to advanced studies of hydrogen and hydrides through exploitation of established expertise at the ERDA weapons laboratories. Superconductivity will continue to be heavily pursued through new fabrication methods such as ternary electron beam deposition, composites, and ion implantation. Surface-catalytic relationships will be accelerated through recent advances in combined Auger, mass spectrometry, computer control systems. New programs in laser light interactions with surfaces and dielectric thin films will be initiated, and synchrotron radiation studies of solar conversion materials will be expanded. The entire area of high temperature materials research in both metals and non-metals will be heavily pursued, particularly in relation to MHD electrodes and insulators, as well as other high-temperature energy system applications. Photovoltaic materials for efficient solar energy conversion will receive considerable attention in the area of deleterious surface losses, and improved coating techniques. Closely coupled to the entire experimental research effort, a sophisticated theoretical research detail will be supported through the use of advanced mathematical models of dynamic material systems and the application of ERDA's most advanced computer systems. The present capability involves as many as 64,000 atom configurations in a dynamic mode so that a wide variety of bulk and surface interactions may be predicted. The complexity of material problems and behavior in advanced energy systems requires the close coupling of experimental and theoretical efforts. As a consequence, an increase of $1,315,000 is requested to support experimental and theoretical research.

Under particle-solid interactions, continued efforts will be devoted to high energy neutron sputtering effects on surfaces which are extremely important to first wall integrity in controlled fusion reactors. Carefully controlled experiments with other radiation sources including heavy ions, electrons, and fission sources will also be undertaken for correlation purposes so that all the mass and energy parameters will be established. The use of precisely thin metal samples will be attempted in radiation damage experiments aimed at determining the onset of damage produced at the beginning of the range of the damage particle; an area that is still unknown. It is aniticpated that all of these radiation damage experiments will continue to be important to fission and fusion material systems. An increase of $190,000 is requested for research in this area, which is closely related to the investigations under the metallurgy and ceramics category.

C. Materials Chemistry .... $ 7,630

Research under the materials chemistry category supports investigations concerning solid state chemistry and all of those chemical phenomena related to material behavior under the extremes of temperature, pressure, and atmosphere. As a result, this research is a bulwark for advances in energy conversion and storage systems. Contributions to the fusion program are expected to result from studies of film resistance to tritium permeation and of the deuterium-tritium phase diagram. Fundamental studies of geothermal scaling and corrosion will provide understanding required to construct models of corrosion behavior in a geothermal environment. Examples of recent accomplishments include the following experimental results: (a) successful separation of five key chemical reactions in the plutonium scrap recovery process at Hanford so that computerized control of fast, safe reaction is operable, and (b) development of a rapid Fourier transform analysis of small dispersed particles so that atmospheric pollution control can be better understood in terms of gas-solid reactions. An increase of $740,000 is requested for this category, to an FY 1977 level of $7,630,000.

The chemical structure detail supports those spectroscopic investigations involving neutron diffraction, electron and x-ray scattering, and laser phenomena, to elucidate the chemical nature of impurity effects in liquid metals and molten salts. In addition, emphasis is given to fundamental structural studies of oxides with a potential for usage in selective catalysis, as well as chemically resistive materials of importance to fossil fuel systems. An increase of $130,000 is requested for this research.

Research under the engineering chemistry detail focuses on basic engineering processes relating to material chemistry systems such as deuterium-tritium-solid interactions, electrolytic cell mechanisms, liquid metal nuclear fuels, the thermodynamics of storage battery reactions, and electrode interface mechanisms. In addition, attention is given to very high temperature kinetics of carbides and nitrides in a host of chemical combinations. All of these efforts provide basic chemical engineering information of importance to energy production, conservation and storage. An increase of $220,000 is requested to advance progress in this area.

The high temperature and surface chemistry detail is concerned with chemical changes related to surface morphologies and very high temperature properties of chemical materials. The former provides the basic underlying processes for surface catalysis phenomena, and the latter accumulates the needed information for understanding mass transport of materials under steep thermal gradients as encountered in advanced energy systems. The most advanced diagnostic instruments are employed in these analyses and include photoelectron spectroscopy, mass and laser spectroscopy, and LEED-Auger scattering apparatus. Research supported under this detail will emphasize the study of surface activity in catalysis and in corrosion at high temperatures. An increase of $390,000 is requested for this research.

3. Molecular, Mathematical and Geo-Sciences .... $ 48,000

This subprogram contains the principal basic energy science effort underlying advances in energy processes themselves. Its goals are the understanding, concepts and data which can lead 1) to new processes tapping new and existing kinds of energy resources, 2) to more efficient and economical energy processes and 3) to less formation of energy-associated pollutants. The research areas shown in the title are composed of four budget categories: two for molecular sciences, one for geosciences and one for mathematical and computer sciences. The fifth category, placed here for convenience, is the educational university-laboratory cooperation.

	Actual FY 1975	Estimate FY 1976	Estimate Transition Quarter	Estimate FY 1977
A. Fundamental Interactions	$ 16,581	$ 18,600	$ 4,700	$ 20,000
B. Processes and Techniques	12,834	14,030	3,600	15,360
C. Geosciences	2,301	2,900	775	3,300
D. Mathematical and Computer Sciences	5,372	5,980	1,525	6,500
E. University-Laboratory Cooperation	2,380	2,600	1,400	2,840
Total Molecular, Mathematical and Geo-Sciences	$ 39,468	$ 44,110	$ 12,000	$ 48,000

Recognition of the relationships of the research areas to ERDA's energy technology concerns will assist in considering the research thrusts discussed below. The following table therefore compares the research dollar levels pertinent to technologies. Because many of the research projects relate to more than one technology, the dollar levels add to more than 100%.

Molecular, Mathematical and Geo-Sciences
Energy Relationships in FY 1977 Operating Expenses Request

	Operating Expenses (Millions)	Amount of effort pertinent to: ($ in Millions)							
		Fossil	Solar	Geothermal	Conservation	Fusion	Fission 1/	Environmental	General Science
Additive	$ 48.0	$ 5.8	$ 4.6	$ 2.3	$ 5.1	$ 4.7	$ 6.6	$ 6.1	$ 12.8
Non-Additive	--	17.2	14.5	8.8	17.7	14.3	16.9	19.1	12.8

1/Includes Nuclear Fuel Cycle

"General science" is that research which is either too basic to identify now with a specific technology, or too widely pertinent to permit assignment to a specific technology.

Focusing first on the two molecular sciences categories, we know that all energy systems (non-nuclear and nuclear) depend on the non-nuclear physical sciences as a wellspring for advances and for solving often unforeseen problems in devising or improving processes in energy technologies. Thus, the continuing goal of the molecular sciences area is basic understanding of non-nuclear chemical and physical interactions, phenomena, processes and techniques. The efforts are planned to meet basic research needs recognized by scientists and engineers as some of the most important in ERDA's technology areas.

The table below shows the reorienting in this subprogram's two molecular categories. It will be seen below that this subprogram has been reoriented over the past few years in order to strengthen its relevance to the various non-nuclear technologies.

Molecular Sciences (Categories A and B only)
Energy Relationships in FY 1977 Operating Expenses Request

Fiscal Year	Operating Expenses (Millions)	Percent of Effort Pertinent to: Fossil	Solar	Geothermal	Conservation	Fusion	Fission	Environmental	General Science
1974	$ 22.4	3%	9%	1%	8%	9%	78%	21%	33%
1975	29.4	17	18	3	12	16	47	23	32
1976	32.6	30	30	3	25	25	31	32	30
1977	35.4	30	27	3	27	22	26	31	30

In the table, fossil energy-related efforts are seen to have been strongly increased, as have the solar- and conservation-related work. The fusion-, geothermal-, and environment-related research has been strengthened, while the fission-related work has been curtailed. These changes are expected to continue, though less dramatically, in the future. With this background, the first two budget categories are discussed more explicitly below:

A. Fundamental Interactions .... $ 20,000

Work in the fundamental interactions category, for which an increase of $1,400,000 is requested, is performed under three budget details: radiation science, chemical physics, and atomic physics. Extremely complicated molecular systems must be dealt with when trying to develop new or better energy sources. Examples are the catalytic conversion of solid fossil fuel to a liquid, the interactions of sunlight with a chemical or biochemical system resulting in the conversion of light to chemical energy, the efficient combustion of a hydrocarbon fuel in an engine, and use of laser photoexcitation of one specific isotope in a mixture leading to its separation from the others present. Understanding of these processes, which is necessary to their efficient development and use, requires study of the detailed reactions of their simplest constituents. These are atoms, molecules, ions, electrons, plasmas and photons. The tools involved are the accelerator, the laser, the computer and a variety of spectrometers which measure the optical and magnetic properties, charge and mass of the atoms, etc., under investigation and permit deduction of their structure and reactivities. Thus, studies of excited states of atoms and molecules can be carried out by physical or chemical means, after creating the excited states by using electrons, light, other forms of radiation, chemical reaction or physical collision. This research is unusually broad in applicability, potentially serving many different technologies simultaneously. Its results will be of importance in MHD, solar energy utilization, combustion, fusion, isotope separation, and environmental effects of pollutants.

The first of this category's three details is radiation science (including photochemistry), for which an $800,000 increase to an FY 1977 level of $9,600,000 is requested. Part of this work underlies solar energy utilization. It includes fundamental studies of the chemistry and structure of chlorophyll and other porphyrins and of the ability of these molecules to harvest diffuse sunlight and then cause electrical charge separation; thus providing a source of chemical energy. In the living plant this energy is used for growth. In the artificial and natural systems under exploration, means are being sought to bypass natural processes and use this energy to decompose water into hydrogen.

A related area is based on the fact that water can be decomposed into hydrogen and oxygen by hard radiation or ultraviolet light. Sunlight reaching the surface of the earth does not contain the proper wave length radiation to accomplish this directly. Current and planned new projects are exploring the use of chemical substances which, dissolved in water, can absorb solar radiation in steps, store it, and then by a series of reactions decompose the water into hydrogen or generate electrical voltage; all with restoration of the added chemicals to their original form to begin the cycle anew. Some systems have already been devised that accomplish this. None is practical at present, so that research into the chemistry of such systems is still needed.

Radiation chemistry and hot atom chemistry probe the chemical consequences of radiation and energetic atoms impinging on matter. The formation and destruction of ozone in the stratosphere is an aspect of this program. For example, the pioneering work identifying some aerosol propellants (fluorochlorocarbons) as potential threats to the ozone layer was supported here. Other aspects are the chemical interactions of energetic deuterons and tritons as they strike the materials of a fusion reactor. A significant effort has explored the early interactions of radiation and electrons with water and aqueous solutions. Just over a decade ago "early" meant a millionth of a second after a radiation pulse. Current research is pushing that time scale down to the governing events at a millionth of a millionth of a second. Scientists working on Division of Military Applications programs at Lawrence Livermore Laboratory have recently made use of the results of these studies of the hydrated electron to develop a dosimeter for very short pulses of radiation, to use in monitoring nuclear explosions, laser fusion and x-ray laser programs. These radiation studies, which originated in a limited scientific need in the nuclear area, are now providing techniques, information and data applicable to a wide range of needs in solar, fission, fusion, conservation and environmental areas.

(Dollars in thousands, except whole dollars in narrative material)

RESEARCH, DEVELOPMENT AND DEMONSTRATION PROGRAMS

BASIC ENERGY SCIENCES PROGRAM: OPERATING COSTS - continued

The second area under fundamental interactions is chemical physics, for which a $400,000 increase to an FY 1977 level of $6,700,000 is requested. Chemical reactivity in general involves two species coming together, exchanging electrons or atoms and/or energy, and then moving apart. In liquids, the reacting species are surrounded by densely packed molecules which complicate and often mask the true chemical reaction. By experimentally arranging for the same reactions to occur in the gas state, the masking is removed and the best insights into the nature of chemical reactions are obtained. Typical techniques for this are molecular beams and laser photochemistry of gases. With the molecular beam technique, individual molecules, atoms or even ions of known energy and composition are directed at targets which are well-characterized systems of atoms and molecules and the collisions take place at known geometries. The results of the interaction (physical scattering or chemical reaction) can be examined to determine the products' nature, mass, energy and scattered direction. This most fundamental knowledge is absolutely essential if one is to be able to predict the outcome of reactions in complex systems where it is not possible to control or measure all of the substances present simultaneously. The complex systems are found in such diverse areas as the combustion of fuels, the chemical effects taking place in fusion reactors, the photochemical separation of isotopes, and the chemistry and photochemistry of pollutants in the atmosphere. Because of these wide importances, atomic beam projects at the national laboratories and several universities will be strengthened. Among those projects are studies of chemi-ionization (a versatile technique for creating ions for such applications as isotope separation), reactions of ozone with nitrogen and sulfur containing molecules where rate constants are needed for environmental and combustion studies, and mechanisms of evaporation of large molecular aggregates which are important in laser fusion and in the mass spectrometric analysis of chlorophyll and other photosynthetic systems.

A second area of chemical physics research, which will impinge on all energy programs, is the theoretical and computational area, with three principal thrusts in quantum mechanics, molecular dynamics and statistical mechanics. These treat the forces that hold molecules together and cause chemical reactions, the specifics of chemical reactions on a molecular level and the behavior of large aggregates of matter such as reacting gases in the atmosphere or gases which react more extensively when exposed to a surface. These endeavors are now ready to be expanded to provide important insights to experimentalists through the availability of large computers and sophisticated programs. An attempt will be made to provide in an efficient and centralized way the use of both computers and computer programs to theoreticians and experimenters handling problems of strong significance through the formation of a National Resource for Computation in Chemistry (NRCC). In two studies, the last of which was completed in June 1975, the National Academy of Sciences-National Research Council has strongly recommended that such a Resource be established and has recommended guidelines for its structure and organization. Budgeting for this Resource is proceeding jointly with the National Science Foundation because of the Resource's strong promise in energy fields and chemistry in general.

New theoretical programs planned include studies of photochromism in molecular systems (the reversible color change which some substances undergo when exposed to light) to explore the potential for utilization of this effect in energy storage. Experimentally, new studies are planned on light emission resulting from chemical reaction in a variety of systems with laser potential. Two other projects here deal with the combustion characteristics of present hydrocarbon fuels and potential alternate fuels (such as methane and alcohol) when burned under controlled conditions. The use of lasers as non-destructive, non-interfering tools in the spectroscopic analysis of the combustion process is impressive in this. Because of their wide importance in fuel use development, these projects will be expanded.

The third area under fundamental interactions is atomic physics, for which a $200,000 increase to an FY 1977 level of $3,700,000 is requested. In this area there are many opportunities for strong and broad guidance of ERDA technologies; especially fusion, solar energy, energy conservation and fossil-MHD. Plasmas are of vital importance in fusion systems and in MHD devices. Fusion-related studies will continue the effort of measuring ionization and excitation cross-sections of already highly charged impurity ions likely to be present in fusion devices. Fundamental studies will be started of the reactions generating plasmas in coal-fired MHD devices and of the bases for maximizing their densities and lifetimes. Research on lasers is another important aspect to be continued, both because studies of photochemistry and excited states are important in the understanding and development of lasers and because lasers are such important tools in the experimental studies of isotope separation, combustion, fusion, energy conversion and storage and the environment. An exciting development during the past year was the discovery that use of excess neutrons in a nuclear reactor to stimulate gas laser action without electrical power input can produce much higher laser power than ordinary gas lasers.

B. Processes and Techniques .... $ 15,360

The advancement of energy technology depends to a great extent on improved understanding of the basic processes by which matter and energy interact. It also requires continuing improvement in our abilities to measure and quantify such behavior in order to predict it when systems are perturbed, and to apply our knowledge of this behavior for engineering design. It is not to be expected that ERDA's principal mission of relative energy independence for the Nation can be achieved with existing technology. To meet the goals of resource conservation and efficiency in use, minimum environment insult and acceptable future energy costs; new concepts will almost certainly be required along with much improvement in existing technology. Equally important, ERDA's efforts to achieve relative energy independence by 1985 will not solve the Nation's longer range problems. A strong fundamental research program oriented toward these problems and developed in a timely manner is urgently needed to provide the basis for their solution.

The processes and techniques category includes four areas: chemical energy, separations, analysis, and a new budget detail titled engineering sciences. The emphasis is on fundamental understanding and high quality scientific data upon which the more applied research programs can draw. The systems and subsystems chosen for study are those in which chemical and physical changes appear particularly suited for energy storage, conversion or generation. Reliable techniques for the measurement of these changes, for modeling the systems or subsystems of concern, for carrying out the energy and mass transfer to effect these changes, and for the control of the processes involved are vital to any energy technology effort. The most basic efforts here involve experimental and theoretical studies of chemical reactions that are pertinent to areas of interest to ERDA. Other of these efforts build understanding of systems which are being developed in ERDA technological programs, and also systems in which basic research results suggest new approaches or define new opportunities. Evaluation of these opportunities, with corresponding identification of needed research in the basic sciences and in the engineering sciences, will be pursued. The requested increase of $1,330,000 for processes and techniques will strengthen recently initiated projects and start carefully selected new efforts suited to ERDA's full scope of responsibilities, in the manner described below.

An increase of $760,000 in chemical energy, to an FY 1977 level of $6,660,000, will allow some strengthening of the promising efforts related to fossil energy, catalysis, hydrogen production techniques, hydrogen storage and conversion of waste to fuels. Typical of those related to fossil energy are: transport mechanisms of hydrogen through solvents used in the liquefaction of coal, mass spectroscopic studies of nondestructively distilled coal constituents and reaction intermediates, and basic organic chemistry of the coal constituents, such as asphaltenes, in order to understand the fundamental reactions involved in their conversion. This area also supports research in appropriate and centrally important areas of catalysis. The emphasis is to understand the fundamental effects on chemical reactions by commercial and specially prepared catalysts, under vacuum and pressure conditions which will help establish a correspondence between the fundamental surface physics and the characteristics of reactions under practical conditions. Of particular interest are the factors which lead to deactivation of catalysts as well as subsequent regeneration.

Initial studies on hydrogen formation indicate that use of heat to dissociate water molecules into hydrogen and oxygen by a sequence of chemical reactions appears feasible at practical efficiencies. Experimental verification of such reaction schemes, by way of an extensive exploratory effort in reaction kinetics and thermochemical measurements, is essential before economic evaluations will be possible. For the storage of hydrogen as hydrides, practicality will partly depend on the rates of hydrogen movement to the reacting sites of the host metallic systems and partly on parameters affecting hydride capacities. Thus, research efforts here seek to understand the structural, transport and thermodynamic properties of known hydride systems well enough to predict the characteristics of more desirable compositions. The conversion of cellulosic wastes such as wood, paper and plant stalks to alcohol by complex enzyme reactions, followed by fermentation, is hindered by the presence of lignin. Current research on such problems attempts to understand the mechanisms of interaction of strong acids and multiple enzymes on cellulose systems. Emphasis is additionally given to techniques which have potential for practical applications, such as immobilization of enzymes, to lower separation costs in such processes.

Fundamental properties which can be used to distinguish one substance or species from another form the very broad spectrum of separations research; ranging from the separation of molecules, which differ only in the alignment of the magnetic fields of their spinning nuclei, to the agglomeration of particles for removal of undesirable fine solids from thick viscous tars during liquefaction of fossil fuels. Basic research on separations processes seeks to discover new methods and to improve existing methods. It relies upon good fundamental data and analytical methodology. Results often find rapid application in the technological market place due in part to the fact that separations research is not a scientific discipline per se. Researchers in this area include chemists, physicists, mathematicians, biologists and engineers. The mix of disciplines assists smooth technology transfer. An increase of $250,000 is requested, to an FY 1977 level of $3,600,000, in order to maintain the effort.

Prior to the formation of ERDA, separations research was primarily concerned with the nuclear fuel cycle; it involved the separation of uranium and thorium from their ores, the purification of their compounds, and the dissolution of spent fuel. That part of separations research principally related to nuclear energy is now focused on spent fuel processing in order to provide to those responsible for final disposition of radioactive wastes the knowledge necessary for a satisfactory solution. In addition, as more efficient and less costly separation processes and equipment become available, the prospect of using isotopically altered fusion equipment components to minimize neutron-induced radioactivity begins to appear feasible. Further, enrichment or depletion of a particular isotopic component often requires two different methods, since a single method is not optimum in all concentration ranges. The so called "nonextractable" portion of plutonium observed in process waste streams has been decreased using phosphorous based extractants, and measuring the effect of light on plutonium solutions has provided some additional clues concerning this "unextractable" portion.

It has become apparent that the same types of separations knowledge useful in nuclear technologies are also useful in nonnuclear energy advances. They bear importantly on possibilities for minimizing energy usage by more effective and economical extraction of valuable minerals and by removing deleterious substances from geothermal brines. Also, the group whose research led to the commercial recovery of uranium from phosphoric acid plants is now making progress on the recovery of uranium and radium from ore tailings and coal fly-ash. Conservation of energy by more efficient hydrogen production is a likely result of separations research connected with problems of thermochemical hydrogen-forming cycles. The basic chemistry involved in the use of slag-molten metal interfaces for effecting separations will be studied in combinations proposed for simple decontamination and recycle of valuable metals. Tremendous savings of energy could result from applications of this work.

A very practical problem in research is that of accurate measurement. This is particularly true when it is necessary to identify and accurately measure an unknown material. Progress in research, development and successful implementation of technology is very much dependent on <u>analysis</u> capability. The utility of fundamental data obtained depends upon the analysis techniques used, and their reliability and sensitivity. Therefore, there is a continuing need for a strong, responsive research effort for improvement in laboratory analytical capability. A $20,000 increase to an FY 1977 level of $4,800,000 is requested for analysis research. Precise chemical and physical analysis and characterization of samples of widely varying nature and complexity are vital to all of ERDA's programs. The thrust here is to create the most advanced state-of-the art analysis capabilities and facilities for support of ERDA laboratory and field programs. Collaborative research with specialists in other fields is also carried out where advanced analytical capabilities are crucial to the research involved, or where new techniques for analytical separations and instrumentation are being moved into larger scale application.

The current scope of analysis research includes new spectroscopic concepts with laser excitation sources, other analytical applications of lasers, in-line energy process control measurements, computer applications to analytical instrumentation, chromatography, nuclear analysis techniques, measurement of radioactive emissions, and measurement of organic and inorganic trace substances in coal and in environmental samples. New and strengthened efforts, made possible by reorienting, will include applications of diode lasers in monitoring the atmosphere, nuclear particle microscopy, combined atomic absorption and mass spectrometry for simultaneous measurement of atoms, ions and molecular species, a direct air-inlet mass spectrometer, and application of prompt gamma-rays to the nondestructive determination of trace element concentrations. An example of valuable collaborative research involving analysis, biomedicine and physics is a study of the medically important determination of body calcium by measurement of argon in the breath. This work will exploit the unique low-level analysis techniques for argon-37 that were developed in conjunction with the solar neutrino experiment.

Continual progress in advancing the frontiers of basic science brings with it the opportunity and responsibility for continuous development in engineering sciences through early assimilation of new scientific knowledge. A new budget detail of engineering sciences is required, because in addition to the studies concerned with the fundamental properties of the substances involved, and the development of suitable processes, an understanding of the scale-up behavior of the systems of interest is vital. This particularly involves the phenomena of mass and energy transport and reaction kinetics. In recognition of this set of problems, and to provide a focal point for relevant studies, $300,000 is requested to establish a program in engineering sciences. This area has its roots in basic science but carries knowledge further toward applicability.

The engineering sciences pertinent to the responsibilities of the molecular, mathematical and geo-sciences subprogram are: fluid mechanics, engineering thermodynamics; mass and energy transport and rate processes; particle dynamics; aspects of electrical or electronic engineering; and instrumentation and control engineering. Engineering analysis and design are also included, and involve greater emphasis on systems analysis to define problems and solutions, rather than on the development of the techniques from basic principles for solution of particular problems. Analysis of the engineering science aspects of ERDA's major efforts in fossil, solar and geothermal energy will identify aspects which can help improve the efficiency, reliability and unit cost of delivered energy. The areas for initial study will then be selected from among fluidized bed processes, which are important in treating plutonium bearing wastes and coal combustion, separations studies, control techniques and fluid dynamics studies, including the behavior of high pressure jet systems.

C. Geosciences .... $ 3,300

The geosciences category supports basic research to increase and improve the methods by which man may obtain usable energy in its many forms. The most immediate use of this work will be in geothermal energy. Other thrusts include research work pertinent to energy facility siting; and geological, geophysical, and geochemical studies related to location and evaluation of uranium, coal, and oil deposits. ERDA is committed to the objectives of developing the extraction of useful geothermal energy from the earth and understanding and measuring the extent of fossil fuel reserves. In support of these commitments, more understanding is needed of the structure, composition and history of the earth's crust. As with the two Molecular Sciences categories, the geosciences category has been a principal focus of reoriented effort since FY 1974, as the following table shows:

(Dollars in thousands, except whole dollars in narrative material)

RESEARCH, DEVELOPMENT AND DEMONSTRATION PROGRAMS

BASIC ENERGY SCIENCES PROGRAM: OPERATING COSTS - continued

Geosciences (Category C)
Energy Relationships in FY 1977 Operating Expenses Request

Fiscal Year	Operating Expenses (Millions)	Percent of Effort Pertinent to: Fossil	Solar	Geothermal	Conservation	Fusion	Fission	Environmental	General Science
1974	$ 1.4	36%	14%	36%	-%	-%	93%	43%	36%
1975	2.3	65	22	87	17	-	87	35	30
1976	2.9	79	24	90	69	-	66	38	28
1977	3.3	79	19	79	79	-	52	45	27

The principal current efforts include studies of controlled fracture, rock permeability, geochemistry, thermodynamics of geothermal brines, and igneous processes. New efforts will include development of instrumentation, techniques for surfacce detection of subsurface features, and initiation of a lava lake experiment to study the behavior of molten rock <u>in situ</u> and problems. An increase of $400,000, to an FY 1977 level of $3,300,000, is requested to maintain the current program and for small increases in geochemistry, geology and geophysics.

Typical of the value of new and expanded research activities to be undertaken in support of geothermal energy, solar and fossil fuels are these examples of accomplishments during the past year: The first laboratory and field measurements of rock permeability at elevated temperatures have been made at Los Alamos (granite, 200^{o} centigrade); of vital importance to many engineering aspects of geothermal power generation, general equations have been formulated at Berkeley which predict the thermodynamic properties of concentrated brines to temperatures as high as 300^{o} centigrade; the first computer program which covers three-dimensional geothermal systems where water and steam co-exist has been developed at Berkeley to model the flow of heat and fluids in geothermal systems, to evaluate the size of a geothermal reservoir and to predict the effects of different rates of energy withdrawal, well spacing and reservoir properties on ultimate energy recovery.

D. Mathematical and Computer Sciences .... $ 6,500

The extensive ERDA investment in advanced scientific computing systems at its laboratories is required for two primary scientific and technological purposes: (1) to automatically acquire and analyze experimental data, and (2) to investigate by numerical means the solution of mathematical models of complex physical or economic systems. The potential for increasing the effectiveness of many ERDA programs and for reducing project costs can be realized by improving the mathematical methods required to formulate and solve such models and by improving the efficiency with which computers are applied. Research in the mathematical and computer sciences category is intended to help realize this potential. Here, too, reorienting of research to meet ERDA's changing needs has been proceeding since FY 1974, as the following table shows:

(Dollars in thousands, except whole dollars in narrative material)

RESEARCH, DEVELOPMENT AND DEMONSTRATION PROGRAMS

BASIC ENERGY SCIENCES PROGRAM: OPERATING COSTS - continued

Mathematical and Computer Sciences (Category D)
Energy Relationships in FY 1977 Operating Expenses Request

Fiscal Year	Operating Expenses (Millions)	Percent of Effort Pertinent to:							
		Fossil	Solar	Geothermal	Conservation	Fusion	Fission	Environmental	General Science
1974	$ 4.0	-%	-%	30%	50%	70%	93%	88%	37%
1975	5.4	30	30	39	59	70	91	87	31
1976	6.0	40	43	50	72	73	83	83	32
1977	6.5	49	58	66	82	89	74	83	31

An increase of $520,000, to an FY 1977 level of $6,500,000, is required to maintain progress in several areas which can have a critical bearing upon many new ERDA activities. For example, the processes of energy production require the analysis of materials and fluids complicated by factors involving irregular spatial configurations, chemical reactions, and heat transfer. In advanced projects engineering where experience is limited or absent and experimentation is difficult, costly, or impossible, there is a premium on supplementing or replacing physical experimentation by computer studies of the mathematical models which describe these processes. These models almost always take the form of systems of partial differential equations. To carry out computer studies of such models, numerical techniques have to be developed for solving such equations which can be implemented efficiently on already existing computers or ones that will be available in the near future. The state of the art permits existing computers and computing methods to effectively handle partial differential equations in two space variables and one time variable. In fact, it is considerably cheaper at present to calculate some two-dimensional flows than to obtain the same data experimentally. But in many problems without any kind of symmetry, one must deal with three space variables. In this case, calculations at present are costlier and less reliable than tests. Newly designed very advanced scientific computers may be capable of helping bring such problems under effective attack if new numerical methods can be developed to exploit their design properties.

Research in mathematical modeling methods for energy policy studies, including energy-saving options, has also become of central importance. An increased effort will permit the development of improved mathematical models of composite, interrelated energy systems and an exploration of large-scale data handling techniques related to such activities. These are basic techniques required for the analysis and trade-off studies of different technologies such as fossil, nuclear, solar, or geothermal. The increase necessary to maintain these research efforts under the mathematical sciences detail is $200,000.

It is estimated that by 1985 hardware costs will be insignificant in comparison to software costs, a trend which underscores the cost benefits to be gained by a timely increase in computer science research now. If problems are to be solved with the use of computers, their mathematical expressions must be translated into other languages more closely related to those which computers can utilize. Such programming languages, together with a necessarily vast array of software and operating systems, form an important area of computer science activity. With continuing dramatic improvements in computers, the difficulty of automating the production of efficient software for more complex tasks has increased. Further complexity arises in linking many computers together by modern communications devices for new applications and economies.

In FY 1976 an important study of the feasibility of sharing computer resources by networking (software, data bases, specialized computing capability, scientific expertise, etc.) was initiated among several ERDA sites. Initial studies indicate that such networks will provide an important technological base for cooperative software developments among ERDA laboratories and university contractors. These efforts may also have a complementary role in furthering the proposed establishment of the National Resource for Computational Chemistry. For these several purposes, the increase requested for computer sciences is $320,000.

E. University-Laboratory Cooperation .... $ 2,840

The objective of this special category of university-laboratory faculty and student research participation is to strengthen and broaden the base for assuring the availability of an adequate supply of university-level trained manpower to help meet ERDA's responsibilities. Research participation under this category complements and contrasts with both normal employment and other forms of association by which students and junior faculty normally further their education in major ERDA research centers and university laboratories. University-laboratory cooperation provides a unique mechanism for encouraging education-oriented research participation by educators and students at ERDA laboratories outside regular employer-employee relationships, thus fulfilling the above-stated objective. Interactions between ERDA laboratories and the university community are strengthened through faculty research participation, graduate students doing dissertation research, other assignments of promising graduate and undergraduate students, and in some cases precollege students, working side by side with experienced scientists and engineers. They receive instruction and use equipment not available on their campuses, while at the same time contributing their talents to the host laboratories' missions. Supporting tasks are included when necessary for effectiveness, such as lectures, seminars, and short courses. Funds are provided for stipends, expenses, and tuition where applicable.

Included under this category is provision for a special minority-oriented precollege student support program called PREFACE (Pre-Freshman And Cooperative Education). This modest but highly effective activity (about $50,000 - $60,000 annually) is specifically directed toward the upgrading of minority and educationally disadvantaged students to college levels, and is administered by ERDA's Office of Equal Opportunity.

Participation under this category is not restricted to the basic physical sciences, but covers all disciplines and programs of interest to ERDA. Since all research participants must be acceptable to the host laboratory and engage in laboratory-approved projects only, all activity is in direct support of that laboratory's mission. Thus, functioning for professional manpower development in all of ERDA's areas of science, this type of university-laboratory cooperation has demonstrated its effectiveness over a twelve year period, although operating well below capacity of ERDA facilities. Assistance to students and young faculty remains one of the best means of attracting talented people to the careers on which ERDA's success depends.

An increase of $240,000 to an FY 1977 level of $2,840,000 will allow needed cost-of-living increases for participants and provide for assignments to some of the Energy Research Centers, as well as participation in nonnuclear areas at the other ERDA laboratories. Research supportive activities, such as conferences, seminars, short courses, practice schools, and traveling lectures, will be continued, and innovative ideas explored.

U. S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
FY 1977 Budget Estimates
Appropriation - Plant and Capital Equipment
(Dollars in thousands, except whole dollars in narrative material)

RESEARCH, DEVELOPMENT AND DEMONSTRATION PROGRAMS

BASIC ENERGY SCIENCES - PLANT AND CAPITAL EQUIPMENT OBLIGATIONS

PROGRAM STATEMENT

	Actual FY 1975	Estimate FY 1976	Estimate Transition Quarter	Estimate FY 1977
A - Obligations for Construction Projects	$ 12,652	$ 23,091	$ 1,315	$ 28,300
B - Obligations for Capital Equipment Not Related to Construction	11,415	13,500	3,530	15,400
Total Obligations for Plant and Equipment	$ 24,067	$ 36,591	$ 4,845	$ 43,700

Obligations for the Basic Energy Sciences program for FY 1977 are estimated at $43,700,000 of which:

a. $28,300,000 is for the construction projects listed in Section A below, (1) requested for authorization in the proposed Authorization Bill, or (2) were previously authorized and for which a request for appropriation is being made in FY 1977.

b. $15,400,000 is for Capital Equipment Not Related to Construction justified in Section B below, requested for authorization in the proposed Authorization Bill.

(Dollars in thousands, except whole dollars in narrative material)

RESEARCH, DEVELOPMENT AND DEMONSTRATION PROGRAMS

BASIC ENERGY SCIENCES: PLANT AND CAPITAL EQUIPMENT OBLIGATIONS - continued

SECTION A - Obligations for Construction Projects

The projects comprising Section A, which are requested for authorization or which were previously authorized and for which a request for appropriation is being made, are:

Project No.	Title	Total Estimated Cost	Funded Thru FY 1976	Estimated Obligation Transition Quarter	Estimated Obligations FY 1977	Future Funding Required to Complete Project
77-8-a	Accelerator and reactor improvements and modifications, various locations	$ 1,300	$ 0	$ 0	$ 1,300	$ 0
77-8-b	Expanded experimental capabilities, Bates Linear Accelerator, MIT	5,000	0	0	5,000	0
77-8-c	Increased flux, high flux beam reactor (HFBR), Brookhaven National Laboratory, New York	2,500	0	0	2,500	0
77-8-d	Conversion of steam plant facilities, Oak Ridge National Laboratory, Tennessee	12,200	0	0	12,200	0
77-14	General plant projects	7,300	0	0	7,300	0
	Total	$ 28,300	$ 0	$ 0	$ 28,300	$ 0

EXPLANATION OF PROJECTS IN SECTION A

1. 77-8-a Accelerator and reactor improvements and modifications, various locations .... $ 1,300

This project provides for additions, modifications, and improvements to research accelerators and reactors, and ancillary experimental facilities. The requested funds are necessary to maintain and improve reliability and efficiency of operations, and to provide new experimental capabilities as required for execution of the planned research program. For example, funds of this type have been utilized to build new beam lines and experimental areas at several accelerator facilities. This has made it possible to run several experiments simultaneously, thus greatly improving the efficiency of accelerator utilization. Facilities which compete for funds requested under this project include, among others, the

(Dollars in thousands, except whole dollars in narrative material)

RESEARCH, DEVELOPMENT AND DEMONSTRATION PROGRAMS

BASIC ENERGY SCIENCES: PLANT AND CAPITAL EQUIPMENT OBLIGATIONS - continued

Clinton P. Anderson Meson Physics Facility, Bevatron/Bevalac, SuperHILAC, Oak Ridge Isochronous Cyclotron and Oak Ridge Electron Linear Accelerator, Bates Linear Accelerator, 88" Cyclotron at Berkeley, High Flux Beam Reactor and Tandem Van de Graaff at Brookhaven, and the Ames Research Reactor.

In view of rapidly changing research requirements, no determination has been made as to the allocation of these funds among the various locations, or as to the subprojects which will be finally selected. In order to assure most efficient utilization of funds, final selection will be made near the beginning of FY 1977, based on programmatic requirements at that time. No significant R&D program is anticipated as a prerequisite for design and construction of the subprojects under consideration.

Listed below are those accelerators and reactors which appear at this time to be leading candidates for the funds requested.

A. Argonne National Laboratory		$ 125
1. Model FN Tandem Van de Graaff	$ 125	
B. Chicago Operations Office		270
1. Bates Linear Accelerator	270	
C. Lawrence Berkeley Laboratory		430
1. Bevatron/Bevalac	310	
2. SuperHILAC	120	
D. Los Alamos Scientific Laboratory		475
1. Clinton P. Anderson Meson Physics Facility	475	

2. 77-8-b Expanded experimental capabilities, Bates Linear Accelerator, MIT .... $ 5,000

This project will provide a second experimental hall together with a supporting data acquisition and control building, and an addition to the existing lab-office building to house laboratories, offices, shops, and an equipment assembly area. As presently conceived, the experimental hall would be approximately 15,300 sq. ft. gross area with 4 feet to 10 feet thick walls and 4 feet thick roof; all of reinforced concrete, covered with earth fill of approximately 9 feet thick. The hall will have a high bay area of approximately 7,700 sq. ft. net area and 40 feet clear height, served by a 45 ton bridge crane; and a smaller high bay area of approximately 15 feet clear height and 3,000 sq. ft. net area, served by a 10 ton bridge crane. The data assembly and control building will be constructed of masonry or steel frame adjacent to the experimental hall. It will be approximately 2,460 sq. ft. gross area and will be connected to the experimental hall and the existing lab-office building by combination utility-pedestrian tunnels. The addition to the lab-office building will be approximately 9,600 sq. ft. gross area of which approximately one third will be single story high bay space (23 feet high) served by a 20 ton bridge crane, and approximately two thirds will be a two story lab-office extension. Both will be of masonry construction on steel frame. Sitework will include a paved parking area and gravel access road (9,500 sq. ft.), a concrete paved experimental yard (15,000 sq. ft.), and an earth berm for added shielding of approximately 10,000 cu. yds. Utilities will be extended from existing plant services.

The deployment and utilization of important secondary sources of photons, neutrons, pions and muons require a second experimental area. With the high intensity and duty factor of this machine, a research program of much greater breadth will be implemented. At the time of initial construction of this facility, the National Science Foundation had also planned to establish a major electron accelerator facility at Stanford University. However, as a result of difficulties experienced in the accelerator technology which was to be adopted the National Science Foundation no longer plans to proceed with establishing the facility. Therefore, the potential capability of the Bates accelerator for electronuclear physics is unique in the United States and only one other facility in the world (Saclay, France) is comparable. Within the past few years, a number of universities and institutions have shown definite interest in doing research with the facility. Potential users have expressed strong intent to implement experiments at the earliest possible opportunity consistent with the extent and adaptability of facilities. Both the range of experimental possibilities and the ability to respond significantly to user requirements for independent original research make essential the construction of this separate general purpose experimental area.

The current lack of space at the facility is a significant impediment to efficient research operations. Six trailers are in use as office space, which is possible only because a temporary variance to city ordinances has been granted. The current limited shielding around the Spectrometer Room will make operations with beams of varying intensities difficult, in that more expensive portable shielding will have to be moved around for different beam set-ups. The additional earth shielding will minimize down-time and permit greater flexibility in experiments. No significant R&D prerequisite to the design and construction is requested and increased operating costs are expected to be minimal.

(Dollars in thousands, except whole dollars in narrative material)

RESEARCH, DEVELOPMENT AND DEMONSTRATION PROGRAMS

BASIC ENERGY SCIENCES: PLANT AND CAPITAL EQUIPMENT OBLIGATIONS - continued

Details of Cost Estimate*

		Item Cost	Total Cost
a. Engineering, design and inspection costs @ approximately 20% of construction costs, Item b			$ 650
b. Construction Costs			3,340
(1) Improvements to land, site development, walks, roads, earth shielding, etc.		$ 170	
(2) Buildings**		2,180	
(a) Experimental Hall, approximately 15,300 sq. ft. @ about $93/sq. ft.	$ 1,420		
(b) Data Assembly and Control Bldg., approximately 2,460 sq. ft. @ about $81/sq. ft.	200		
(c) Laboratory and Utility Buildings approximately 9,600 sq. ft. @ about $56/sq. ft.	560		
(3) Other Structures - passageway and pumphouse		80	
(4) Special Facilities (beam transport system, etc.)		790	
(5) Utilities, water, sewer, electric, etc.		120	
c. Standard Equipment			370
Subtotal			4,360
d. Contingency @ approximately 15% of above costs			640
Total Project Cost			$ 5,000

3. 77-8-c Increased flux, high flux beam reactor (HFBR), Brookhaven National Laboratory, New York .... $ 2,500

This project provides for the modification of the HFBR to permit operation at 60 megawatts (Mw), an increase of 50 percent above the current operating level of 40 Mw which will increase the neutron flux by the same amount. The principal modification required is the replacement of the two primary heat exchangers with larger ones. Minor changes are needed to augment the secondary cooling water and emergency cooling systems and to re-range instrumentation systems. The new heat exchangers will have an approximate increase of 50 percent in heat transfer area, thus the volume of water required to fill the heat exchangers, on both the primary and secondary sides will also be larger. Since the primary side fluid is heavy water (D_2O), the additional amount required is treated as a project cost item. The reactor proper requires no further shielding for 60 Mw operation. The installation of the heat exchangers will control the estimated reactor downtime of two months. Therefore, a major goal will be to prefabricate, preinspect and test, so as to minimize reactor downtime.

*Based on completed conceptual design.
**Relatively high unit cost is due to requirements for thick reinforced concrete construction and higher than normal roof.

Modifications to the emergency cooling system are necessary, because recently conducted laboratory tests indicate that some core overheating may occur during the flow reversal period which follows emergency shutdown from 60 Mw. The modifications being proposed will delay the onset of flow reversal until the danger of overheating no longer exists. The remainder of the construction will be in the cooling tower system. This will necessitate enlarging one of the two sumps, some pipe modifications and the enlargement of one of the filter flumes.

The HFBR has proven to be a highly successful reactor both in achieving its original design objectives and as an important research facility. As a result, Brookhaven scientists and users from universities have been able to undertake forefront investigations which could not be considered on a practical basis at any other laboratory. With new high flux research reactors abroad, however, our position is being challenged. The French-German reactor at Grenoble, in particular, now in full power, is designed to provide a maximum thermal neutron flux twice as high as that of the HFBR, and under experimental low background conditions comparable to the HFBR. The proposed power increase for the HFBR is required in order to permit work on new experiments which are either marginally feasible at present, or require so much reactor time as to create severe scheduling problems. Definitive work on anharmonicity effects on phonon lifetimes, for example, has been greatly limited by available intensities. The pioneering work at Brookhaven in "dynamic crystallography" has opened up a new field of far-reaching significance in solid state physics, but its exploitation is restricted at present to very simple cases. Many problems, especially those involving use of separated isotopes in short supply, are sample-size-limited. The reason little real progress has been made on the liquid state, especially with regard to dynamical properties, has been largely that of inadequate neutron intensities for beam experiments. The new Cold Neutron Moderator will represent a significant enlargement in scope for the overall research program at the HFBR. However, among the many new types of experiments made possible by this important new facility, some in the wavelength range of greatest potential interest will be only marginally feasible. Finally, experiments at Brookhaven have demonstrated that neutron scattering can provide a powerful tool in protein crystallography, and some striking improvements in instrumentation and techniques for such work are now under development. Nevertheless, these experiments will require a great deal of reactor time. Therefore, an increase in beam intensity can be translated directly into either time-saving on one of these important experiments, or an enlargement of its scope. No significant R&D program is anticipated as a prerequisite for design and construction of this project. The increase in reactor operating costs as a result of this modification is estimated at $200,000 per year.

(Dollars in thousands, except whole dollars in narrative material)

RESEARCH, DEVELOPMENT AND DEMONSTRATION PROGRAMS

BASIC ENERGY SCIENCES: PLANT AND CAPITAL EQUIPMENT OBLIGATIONS - continued

Details of Cost Estimate*

		Item Cost	Total Cost
a. Engineering, design and inspection costs at approximately 15% of item b, construction costs			$ 210
b. Construction Costs			1,420
(1) Improvements to land		$ 0	
(2) Building		0	
(3) Other structures (cooling tower modifications)		100	
(4) Special facilities		1,320	
(a) Heat exchanger installation, including process piping and reactor instrumentation changes	$ 120		
(b) Procurement of two heat exchangers, including required engineering and special fabrication to fit existing cell	1,190		
(c) Procurement, installation and testing of DC motors and battery supply	10		
c. Standard Equipment			0
d. Heavy Water - 14,000 lbs.			550
Subtotal			2,180
e. Contingency @ approximately 15% of above costs			320
Total Project Cost			$ 2,500

4. 77-8-d Conversion of steam plant facilities, Oak Ridge National Laboratory, Tennessee .... $ 12,200

Steam requirements at Oak Ridge National Laboratory are supplied from five gas-oil fired boilers having a combined rated steam production capacity of 300,000 pounds per hour. The central steam plant facilities constructed in 1947 consisted of three coal-fired boilers with auxiliary equipment. These units were converted in 1950 from coal to gas-oil firing, and the coal handling equipment was removed. Two additional gas-oil fired boilers were installed in 1956 and 1963 respectively. The proposed conversion of four of the units to coal-oil firing will require alterations and additions to the existing steam plant facilities including the installation of stokers, grates, electrostatic precipitators, draft fans, and coal and ash handling equipment; the construction of coal yard facilities and a control room; modifications to existing stack breeching for the installation of the precipitators; and upgrading the electrical systems to handle the

* Based on completed conceptual design.

increased power loads. A fifth boiler unit was designed specifically for gas-oil firing and cannot be altered for coal-oil service. A steam line (approximately 1-1/2 miles in length) will be extended to the shops, stores, and warehouse area, because the heating for the buildings will be changed from gas-fired unit heaters to steam-coil space units. An automatic sprinkler fire protection system will be installed in the steam plant building to conform to existing code requirements.

The impending shortages of both gas and oil for fuels, plus government policies aimed at curtailment of these fuels for steam production, precipitates the need for immediate action to provide funds for the conversion of existing facilities to fossil fuel for the production of steam. Temporary additional oil storage capability was installed at the laboratory to provide a reserve fuel capacity for approximately three weeks. Based on the limited storage capacity, an interruption of oil supply would result in severe curtailment and possibly complete shutdown of the Laboratory's operations. Approximately ninety percent of the total steam produced is used for essential heating and operating purposes, while the remaining ten percent is for heating low-priority buildings which could be placed on an as-needed schedule to prevent freezing of sprinkler systems or stored materials.

The shops, warehouse, and stores area facilities use gas-fired unit heaters during the heating season. During the heating season of 1974-1975, the gas supply was completely shut off to that area about eighty percent of the time, forcing the use of portable oil-fired heaters on limited and selective bases. These units were not permitted in buildings having high risk values, such as paint shops and in storage areas containing flammable materials.

Details of Cost Estimate*

		Item Cost	Total Cost
a. Engineering, design, and inspection at 15% of construction costs, item b			$ 1,320
b. Construction costs			8,880
(1) Improvements to land		$ 180	
(2) Building Modifications		90	
(3) Utilities		8,610	
(a) Conversion of existing boilers	$ 7,110		
(b) Steam line and heating units conversion	1,500		
c. Standard equipment			0
Subtotal			10,200
d. Contingency at approximately 20% of above costs			2,000
Total Project Cost			$ 12,200

*Based on completed conceptual design

(Dollars in thousands, except whole dollars in narrative material)

RESEARCH, DEVELOPMENT AND DEMONSTRATION PROGRAMS

BASIC ENERGY SCIENCES: PLANT AND CAPITAL EQUIPMENT OBLIGATIONS - continued

5. 77-14 General plant projects .... $ 7,300

This project is required to provide for minor new construction, other capital alterations and additions, and for retirements to land, buildings and utility systems. Where applicable, the request also includes the cost of installed capital equipment integral to a subproject. Funding of this type is essential for maintaining the productivity and usefulness of ERDA-owned facilities. Since it is difficult to detail this type of project in advance, a continuing evaluation of requirements and priorities may be expected to result in additions, deletions, and changes to the currently planned subprojects. In general, the estimated funding for each location is preliminary in nature, and is intended primarily to indicate the relative magnitude of the requirements. $4,000,000 is for a special Lawrence Berkeley Laboratory requirement to correct fire, earthquake and safety hazards in order to meet ERDA improved risk criteria. No significant R&D program is anticipated as a prerequisite for design and construction of the subprojects under consideration.

The funds requested for FY 1977 are estimated as follows:

Ames Laboratory	$ 250
Lawrence Berkeley Laboratory	4,000
Los Alamos Scientific Laboratory	200
Notre Dame Radiation Laboratory	10
Massachusetts Institute of Technology	90
Oak Ridge National Laboratory	2,650
Washington - Division of Physical Research	100
Total Project Cost	$ 7,300

SECTION B - Obligations for Capital Equipment Not Related to Construction

Subprogram	Actual FY 1975	Estimate FY 1976	Estimate Transition Quarter	Estimate FY 1977
1. Nuclear Science	$ 5,706	$ 5,675	$ 1,300	$ 5,700
2. Materials Sciences	2,964	3,050	800	4,600
3. Molecular, Mathematical & Geo-Sciences	2,014	2,675	800	2,800
4. Other Capital Equipment	731	2,100	630	2,300
Total Basic Energy Sciences	$ 11,415	$ 13,500	$ 3,530	$ 15,400

JUSTIFICATION

The Basic Energy Sciences request for capital equipment in FY 1977 totals $15,400,000. Because the planned program includes a wide variety of new and expanded research projects in support of ERDA's applied and developmental activities, completely new types of advanced scientific equipment are required which cannot be made available by upgrading or modifying existing equipment. As a consequence, the productivity of the research program will depend directly on the availability of proposed experimental apparatus based on the most advanced technology. Included within the request is $1,600,000 for a high voltage electron microscope at the Lawrence Berkeley Laboratory. Since the equipment requested is required to carry out the planned research program, which is multidirectional, the items justified below generally are applicable to more than one energy technology area. Because the Basic Energy Sciences program is at the forefront of science, it is difficult to predict in advance the exact specifications of experimental equipment which will have highest priority in FY 1977. The examples described below, therefore, represent projected requirements based on the current experimental program and state of the art.

1. Nuclear Science .... $ 5,700

This research program relies heavily on major scientific research facilities, including accelerators and reactors. These facilities provide the nuclear probes with which the great majority of the research studies are conducted. The equipment requirements for accelerator programs, for example, include maintenance, upgrading and replacement for ion sources, accelerator components, radiofrequency equipment, vacuum systems, beam transport and analysis systems, spectrometers, detection equipment, data acquisition and analysis systems, etc. For those facilities which have been established as national or regional facilities, the need is especially pressing in that they must serve a large user group community in addition to a vigorous in-house effort. In this class are LAMPF, the Bevalac, SuperHILAC, Bates Linac and the Brookhaven double tandem. As the program moves forward in exploiting frontier areas of the nuclear research field, new equipment must be designed and fabricated. This program also has responsibility toward meeting the equipment requirements for the ERDA isotope separation programs carried out at Mound Laboratory and the Oak Ridge National Laboratory as well as for the transplutonium element production at the Oak Ridge High Flux Isotope Reactor - Transuranium Processing Plant complex.

The following is a listing of examples of significant items required in the nuclear science subprogram:

Argonne National Laboratory .... $ 750

Accelerator and reactor facilities at Argonne support a broadly based nuclear research program. Capital equipment requirements center about the FN tandem Van de Graaff, electron linac, CP-5 reactor, dynamitron, and 60-inch cyclotron. In addition to these on-going accelerator and reactor based efforts, capital equipment funds are required for a heavy ion booster accelerator project at the FN tandem Van de Graaff, for LAMPF user group research, and for timely augmentation of the heavy element (actinide) chemistry research program. Specific requirements include: vacuum pumps and controls ($75,000); rf power amplifiers ($40,000);

control electronics ($30,000); quadrupoles and bending magnets ($50,000); on-line data acquisition equipment ($30,000); general purpose electronics ($175,000); target fabrication equipment ($20,000); leak detector ($10,000); magnetic spectrograph modifications ($35,000); minicomputer pulse height analyzer ($35,000); liquid chromatograph ($10,000); multi-channel analyzer ($30,000); high resolution gamma and particle detector equipment ($90,000); and general purpose laboratory equipment ($75,000).

Brookhaven National Laboratory .... $ 500

The Brookhaven nuclear science program is carried out using a wide range of highly productive facilities, including the double MP tandem Van de Graaff and the High Flux Beam Reactor, both of which support strong in-house and user programs. There are also active nuclear physics and nuclear chemistry research programs at the Alternating Gradient Synchrotron, LAMPF, the SuperHILAC, and the Homestake Gold Mine in South Dakota. Examples of equipment items making up this request are: Sigma 7 tandem computer facility update ($140,000); improvements and modifications to data acquisition systems at the HFBR and the double MP tandem facility ($100,000); computer terminals and peripherals for the National Neutron Cross Section Center ($50,000); modifications to the hypernuclear spectrometer at the AGS ($60,000); extraction system for the solar neutrino detector ($40,000); and general purpose electronics ($70,000).

Oak Ridge National Laboratory .... $ 800

The research program at this laboratory is broadly based and is centered around six major facilities: the EN tandem Van de Graaff, the Oak Ridge Electron Linear Accelerator, the Oak Ridge Isochronous Cyclotron, the Transuranium Processing Plant, the High Flux Isotope Reactor, and the Calutrons. Equipment needs are for nuclear studies in heavy ion, charged particle, heavy element, and neutron research and for the preparation and separation of stable and radioactive isotopes for research. Some examples are: data acquisition electronics ($105,000); particle detectors ($40,000); ion source ($20,000); power supplies ($100,000); beam alignment system ($30,000); electron spectrometer ($35,000); isotope separation components ($115,000); liquid waste treatment system ($30,000); high vacuum systems ($35,000); scattering chamber ($75,000); time-of-flight measurement equipment ($20,000); and general laboratory equipment ($150,000).

Lawrence Berkeley Laboratory .... $ 850

This laboratory conducts the strongest and most diverse program in heavy ion research in the world, and includes not only the in-house groups but extensive participation by outside users. These research activities are centered around three major accelerators: the 88-inch cyclotron, the SuperHILAC, and the Bevalac. Each of these has extensive equipment requirements, including: instrumentation and modular electronics ($150,000); data acquisition equipment ($125,000); full aperture extraction system ($175,000); multichannel analyzer ($20,000); recoil atom mass analyzer ($25,000); neutron counter ($50,000); particle counting equipment ($130,000); and general laboratory equipment ($150,000).

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RESEARCH, DEVELOPMENT AND DEMONSTRATION PROGRAMS

BASIC ENERGY SCIENCES: PLANT AND CAPITAL EQUIPMENT OBLIGATIONS - continued

Pacific Northwest Laboratory .... $ 25

A variety of particle detector and data acquisition electronics are required for the fission product mass spectrometer system.

University of Washington .... $ 30

Equipment needs are those required in connection with the operation and research use of the double FN tandem Van de Graaff system such as: a magnetic control unit, vacuum pump replacements, and quadrupole magnets.

Yale University - 3074 .... $ 100

Capital equipment funds are required for heavy ion and light ion nuclear research and for accelerator operations. Specific items of equipment include: electronic instrumentation ($20,000); particle detector systems ($25,000); general laboratory equipment ($30,000); and accelerator components ($15,000).

Yale University - 3075 .... $ 50

This program supports one of the leading medium energy user group research programs. Capital equipment items needed in this program include: electronics and detectors ($20,000); multichannel pulse height analyzer ($10,000); and high power tunable pulse laser ($20,000).

Off-Site Program .... $ 155

Capital equipment funds are required for support of ERDA-owned accelerator systems at various locations including Duke University, University of Colorado, and the University of Minnesota. Specific items of equipment include: accelerator components ($75,000); time-of-flight equipment for neutron cross section measurements ($25,000); and general purpose electronics ($25,000).

2. Materials Sciences .... $ 4,600

The Materials Sciences subprogram is greatly in need of equipment in order to attack new materials problem areas in all of ERDA's energy programs. Even a cursory examination of existing and proposed energy systems reveals that the energy crisis arises not only from a lack of fuels, but also from the unavailability of materials with properties which allow more efficient operation of existing systems and the technical and economic feasibility of building proposed systems. The equipment request recognizes the need to emphasize research not previously undertaken but of great importance in the total energy plan. The requested funds will be used for equipment needs concentrating on research in areas important to fossil, solar, geothermal and conservation.

Higher operating temperatures and, hence, greater efficiencies of steam and gas turbines are limited by the high temperature mechanical properties and corrosion of materials. The introduction of coal gasification for the production of high BTU gas is not limited by the lack of knowledge of the chemical processes involved but by suitable corrosion and erosion resistant structural materials. The operation of light water reactors is held below maximum capability due to the corrosion of materials, weld failures, and fuel and cladding instability in radiation environments. An economic breeder reactor will depend on new fuels having higher breeding ratios, radiation resistant cladding and structural materials, and materials resistant to the severe corrosive properties of liquid metal coolants. It is not the lack of understanding of basic physics which precludes widespread development of open-cycle coal fired MHD plants, but the inability of existing structural materials to operate in the highly corrosive, extremely high temperature environments. Also, there exist no satisfactory electrode materials to extract the electrical energy nor superconducting materials to incorporate in the high field magnets required. The rapid development of solar photovoltaic electrical generation is limited by the availability of efficient conversion materials and our ability to prepare the materials cheaply. Economic solar thermal energy production is limited by long-term corrosion and uncertainty of materials stability. A one percent increase in efficiency in catalysts could save the nation billions of dollars in petrochemical processing. More specific and stable catalysts would permit more efficient operation of the internal combustion engine. The feasibility of power generation by fusion either by magnetic confinement or laser implosion has yet to be demonstrated. However, when it is, the construction of power plants will require structural materials to operate in severe radiation and ion bombardment environments with surfaces which do not degrade and contaminate the system.

Doubtlessly, demonstration plants will be constructed for all these energy systems using existing materials by means of ingenious engineering design. Nevertheless, none of the systems will become economically feasible without materials of improved capabilities. It is the objective of the Materials Sciences subprogram to increase the understanding of the properties, processing, and behavior of materials to provide a basis for the development of new materials to meet the challenge of these new energy systems. New equipment is urgently required to undertake the new investigations.

Recent rapid advances in understanding of such materials behavior as catalytic activity, superconducting phase transitions, and high temperature properties have largely been brought about by the advent of new experimental techniques, e.g., Auger spectroscopy, inelastic neutron scattering, and positron annihilation spectroscopy. In order to continue a program of forefront research and initiate research in profitable new areas relating to non-nuclear energy systems such as fossil fueled MHD, solar photovoltaic, and laser fusion, these new experimental techniques must be fully utilized. With the present program and planned expansion, new equipment is urgently required in a number of topical areas, for example: surfaces and catalysis ($600,000); neutron scattering ($450,000); solar materials and optical properties ($420,000); high temperature materials ($500,000); particle-solid interactions and radiation effects ($350,000); and defect analysis ($160,000). The equipment requests for neutron scattering and radiation effects represent primarily the needed support for new experimental techniques and facilities such as the radiation effects area of the Los Alamos Meson Physics Facility and the new cold neutron source at the High Flux Beam Reactor at Brookhaven. A high voltage electron microscope at Lawrence Berkeley Laboratory ($1,600,000) is the only major item of equipment required. This microscope has the advantage of increased resolution for high temperature alloy development, increased penetration for studying ceramics, and reduced ionization damage to biological materials.

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RESEARCH, DEVELOPMENT AND DEMONSTRATION PROGRAMS

BASIC ENERGY SCIENCES: PLANT AND CAPITAL EQUIPMENT OBLIGATIONS - continued

A detailed breakdown of the remaining equipment requirements follows:

Aerojet Nuclear .... $ 10

Equipment is needed for studies of corrosion and scaling by brine solutions, which are of interest for systems envisaged for harnessing of geothermal energy.

Ames Laboratory .... $ 350

Equipment is needed in the following areas: surfaces ($30,000); high temperature materials and ceramics ($120,000); hydrides ($30,000); and chemical structure ($120,000). Major pieces of equipment are an x-ray photoelectron spectrometer (XPS) to investigate the bonding and electrical structure of high temperature materials, a photoelectron emission apparatus for catalyst studies, and a Fourier transform infra-red spectrometer for optical studies.

Argonne National Laboratory .... $ 810

Major equipment requirements to expand existing programs and to initiate new ones are in the areas of defects in metals and insulators ($200,000), surface phenomena and catalysis ($180,000), particle-solid interactions ($130,000), lattice dynamics ($140,000), and high temperature materials ($110,000). The main new thrust in the defects area is a program in positron annihilation which is being used to examine point defects, voids, and fracture nuclei in metals and ceramics. The main equipment requirement is for positron detection equipment. Another major facility for defect studies is an ultrasonic apparatus to investigate the near-surface region of solids important for understanding catalytic activity. For the investigation of defects in high temperature oxides a high power laser is required for optical studies and a microwave spectrometer to ascertain defect electronic structures. Major equipment items in the surfaces and catalysis area are a magnet for nuclear magnetic resonance investigation of the chemical bonding of adsorbed molecules and a Raman spectrometer for infrared measurement of surface effects.

Brookhaven National Laboratory .... $ 405

The areas for which extensive new capital equipment is required are neutron scattering ($110,000), superconductivity ($70,000), optical properties ($150,000), and defect studies ($40,000). New spectrometer parts and modifications such as cryostats are necessary for the continuing neutron scattering studies of phase transitions, phonon properties, and magnetic structures of solids. Many of these studies are investigating phenomena which accompany or control the onset of superconductivity. In the area of superconductivity itself, funds are requested for a scanning attachment and an energy dispersive analyzer for a transmission electron microscope. These will greatly expand the capabilities of the instrument for the investigation of nucleation of superconducting materials. The major requirement in the optical properties area are for renovating the radiation source used for the production of optically active defects in transparent refractory materials potentially important in fusion systems.

BASIC ENERGY SCIENCES: PLANT AND CAPITAL EQUIPMENT OBLIGATIONS - continued

Oak Ridge National Laboratory .... $ 810

Equipment is required at this laboratory to enable new research in phonon spectroscopy ($200,000), x-ray diffraction ($100,000) and radiation effects ($120,000). New equipment is of critical importance to recently initiated and expanded programs in surfaces and catalysis ($140,000), high temperature materials ($100,000) and materials for solar energy and optical properties ($120,000). Representative major pieces of equipment include a superconducting solenoid to study materials and phenomena of interest for high field applications in fusion and energy storage magnets. For defect structures research a medium voltage electron microscope is needed for routine microscopy in order to release the high voltage microscope for the specialized work for which it was designed. Other representative large items are: an ultrahigh vacuum Auger photoelectron spectrometer to study absorbed gases on metals of interest as coal gasification catalysts; a high resolution mass spectrometer to examine the high temperature gas phase species during reaction of metals and ceramics in a coal gasification environment and an image analyzer to quantify the corrosion products of high temperature materials.

Lawrence Berkeley Laboratory .... $ 1,900

Primary equipment items necessary to support continuing and new research includes a high voltage electron microscope ($1,600,000) as well as apparatus for the study of surfaces and catalysis ($125,000), high temperature materials including ceramics ($65,000), and electrochemistry ($30,000). The principal advantage of the high energy microscope are increased resolution, increased penetration, and reduced ionization damage to organic materials. This scientifically powerful piece of equipment will significantly extend the already comprehensive electron microscope facilities at Berkeley and will provide the opportunity for a new range of programs which includes: alloy design, oxidation, thermal fatigue, ceramic alloys, characterization of pollutants, and the effects of pollutants on micro-organisms and cell structure. A large item in the surfaces program is a combined gas chromatograph-nuclear magnetic resonance facility for the investigation of the chemical bonding of absorbed gases on solid catalyst surfaces. A major piece of equipment for studying high temperature materials is a mechanical testing apparatus for measurement of the fracture behavior of ceramics.

Lawrence Livermore Laboratory .... $ 20

Electrochemical cells are required to monitor the thermodynamic activities of the various ionic species which are being studied as being potentially important in the hot corrosion process.

Los Alamos Scientific Laboratory .... $ 55

Equipment is required for alignment of the neutron irradiation experiments at LAMPF. Other capital equipment is necessary for the completion of a continuous chemical vapor deposition furnace for the preparation of high critical temperature superconducting tubes and wires.

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RESEARCH, DEVELOPMENT AND DEMONSTRATION PROGRAMS

BASIC ENERGY SCIENCES: PLANT AND CAPITAL EQUIPMENT OBLIGATIONS - continued

Mound Laboratory .... $ 10

Ultrasonic generating and detecting equipment will be used to measure sound velocity in liquid metals from which thermodynamic data will be determined.

Pacific Northwest Laboratory .... $ 80

Equipment is needed to maintain the existing programs on transuranium metals and ceramics. Vacuum parts and fixturing are required for the sputter deposition programs on superconductors and a high power laser is needed for study of reflecting surfaces subjected to a controlled thermonuclear fusion plasma and radiation environment.

Sandia - Albuquerque .... $ 10

Equipment is needed for routine chemical analysis of ion implanted surfaces.

Sandia - Livermore .... $ 10

A gas mixing manifold is required for preparation of hydrogen containing gases for studies of hydrogen effects in metals and hydrides.

Off-Site Program .... $ 130

Equipment is required for surfaces and catalysis ($50,000) and solar materials and optical properties ($60,000). Specific items are a high power laser for flash heating of materials, high power lasers for investigation of optical properties, and a Raman infrared spectrometer to study solid state phase transitions.

3. Molecular, Mathematical and Geo-Sciences .... $ 2,800

Research under this subprogram has been equipment-limited for the last several years. This limitation is now compounded by the necessity to procure new and different types of equipment required by the reoriented research directions undertaken by this subprogram. Funds are required for replacement and upgrading of obsolete equipment, in order to increase the productivity and efficiency of the planned research activities, and for new equipment specifically designed for reoriented ERDA related research.

Following are examples of some of the major equipment items required by each location:

Ames Laboratory .... $ 165

Research activities in new energy-related areas being conducted at Ames Laboratory require laser spectroscopic equipment to study very fast processes typified in photochemical processes. Other special equipment is required to resolve spectra obtained from complex systems (coal for example), and new equipment is needed to examine processes involved in the thermochemical production of hydrogen and its storage in and recovery from metal hydrides. Some of the major items needed are as follows:

A flash lamp-pumped dye laser is to be used for fluorescence line narrowing and resonance Raman scattering experiments to study interactions of light with matter ($22,000). Acquisition of an x-ray photoelectron spectrometer ($40,000) will make it possible to study directly the changes in the valence band energy states as a result of introducing hydrogen into metallic phases. A pulsed radiation source to provide x-ray or super-radiant light ($25,000) will be used to evaluate time resolved phosphorimetric techniques to determine trace organics, e.g. carcinogens, as well as time or time luminescence of solids and gases. ($25,000) is to provide specialized computer communication interface equipment for computer network experiments. Other minor equipment items total ($40,000).

Argonne National Laboratory .... $ 480

Equipment requirements include: variable frequency nuclear magnetic resonance pulse spectrometer ($180,000) for chlorophyll and photosynthesis research related to solar energy conversion, computer equipment ($50,000) for processing gas chromatographic data used in fossil fuel conversion studies, crossed dispersion vacuum spectrograph ($40,000) for dynamic studies of energy transfer processes in plasmas, and a grazing incidence monochromator ($50,000) for photoionization studies and ion-molecule reaction cross sections. Other equipment needs are for fluid catalysis studies and kinetics and thermal studies of hydrogen producing reactions ($50,000); and minicomputer systems and specialized peripheral equipment for the development of a mathematical laboratory ($50,000).

Atomics International .... $ 10

Several minor items of equipment are required for high temperature research on solid fuel processing.

Brookhaven National Laboratory .... $ 480

The major equipment needs include laser and spectroscopic equipment for photochemical and porphyrin studies ($100,000), spectrometer equipment for neutron diffraction and scattering studies at the High Flux Beam Reactor ($90,000), high temperature powder diffraction equipment for x-ray studies of hydrides ($20,000); equipment and instrumentation for the Cooperative Fuel Research (CFR) engine used in combustion studies ($20,000), a superconducting magnet for the CTR-related ion-molecule studies ($100,000), microscopy tools for the analysis program ($20,000); and a heavy ion interaction system for the new atomic physics project ($75,000). Special purpose computer processors, discs, and peripheral equipment are needed for data-base management studies ($50,000).

Oak Ridge National Laboratory .... $ 405

Research on separation processes is one of the specialities of this laboratory. Several equipment items are required in this area, such as modifications and instrumentation for the annular continuous chromatograph ($15,000), a gas analysis system for the fluidized bed contacting studies ($15,000), equipment for the study of the removal of fine particles from viscous liquids ($100,000), equipment for the study of removal of tritium to low levels in the solid blanket CTR concept ($50,000), modifications to a preparative scale chromatograph and a magma counter for study of the control of radioactive aerosols ($10,000). An atomic-absorption spectrometer ($125,000) is required for trace metal analyses in the aqueous solution thermodynamic program. An x-ray monochrometer ($30,000) is required to study photoelectrons emitted from molecules absorbed in surfaces (part of a program on heterogeneous catalysis). Replacement equipment items will require $50,000.

Knolls Atomic Power Laboratory .... $ 40

The allocation is for components needed to maintain and update the mass spectrometers and ion microprobe. The components include electronic power supplies and logic circuits, high vacuum pumps, and readout and data processing equipment.

Lawrence Berkeley Laboratory .... $ 345

The geosciences effort will require high temperature solution calorimetry equipment ($100,000) for thermodynamic studies in naturally occurring solids, liquids and gases. Extension of the studies of the dynamics of intramolecular energy transfer requires a mode locked laser ($30,000). New projects involving basic studies on coal chemistry require a gas chromatograph/mass spectrometer ($100,000) for characterization and identification of components resulting from chemical reactions of coal. Laser-based instrumentation for studies of coal combustion and other equipment requires $60,000. A graphic terminal system for computer science research requires $50,000.

Lawrence Livermore Laboratory .... $ 75

Apparatus designed to study gas media at high temperature and at high pressure is required for studies in the geosciences, hydro-test research and x-ray diagnostics. The computer networking experiments require $50,000 for automatic data processing peripherals.

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RESEARCH, DEVELOPMENT AND DEMONSTRATION PROGRAMS

BASIC ENERGY SCIENCES: PLANT AND CAPITAL EQUIPMENT OBLIGATIONS - continued

Los Alamos Scientific Laboratory .... $ 100

Equipment requirements at Los Alamos include high speed oscilloscopes ($20,000); x-ray fluorescence spectrometer ($30,000) and a variable wave-length detector, recorder, digital integrator and nuclear magnetic resonance probe ($31,000).

Mound Laboratory .... $ 35

In order to maintain the effort on the basics of isotope separation, equipment is needed to improve the diagnostics on the beam chamber used to probe the intermolecular potential function, and to automate the low temperature calorimeter being used to study isotopic solid noble gases.

New York University .... $ 200

Data processing and disc storage equipment are required to modernize the computer system.

Notre Dame University .... $ 125

The equipment funds requested will be used to purchase spectrometric equipment for excitation and luminescence studies, laser equipment for photochemical research, and repair and replacement equipment for the Linac.

Pacific Northwest Laboratory .... $ 190

Equipment needs include stirred autoclaves ($40,000) for a new energy initiative in cellulose liquefaction and an image analyzer ($130,000) for analytical studies.

Sandia Laboratory - Albuquerque and Livermore .... $ 65

The equipment needed is primarily for the geosciences research initiated at Sandia in FY 1975. The request includes funds for a magma multiphase convective flow apparatus and associated equipment.

Off-Site Program .... $ 85

This request provides equipment for tapping new expertise through several off-site contracts.

RESEARCH, DEVELOPMENT AND DEMONSTRATION PROGRAMS

BASIC ENERGY SCIENCES: PLANT AND CAPITAL EQUIPMENT OBLIGATIONS - continued

4. Other Capital Equipment .... $ 2,300

The general purpose capital equipment items to be acquired are essential to support all of ERDA's planned research and development activities at Ames Laboratory, Lawrence Berkeley Laboratory, and the Oak Ridge National Laboratory. In FY 1977, $2,300,000 is required to properly equip laboratory wide service and support functions, such as health physics, plant engineering, medical services, machine shops, instrumentation, and central scientific computer systems. The request also provides for equipment required to meet federal or ERDA fire, safety and environmental standards. Thus, the productivity, efficiency, and safety of ERDA's programs at these laboratories is directly related to the equipment items included under this category.

Examples of major equipment items required by each contractor are as follows:

Ames Laboratory .... $ 100

A number of equipment items must be modified and upgraded to meet safety standards ($80,000). Examples are specialized guards, controls and switches for shop and maintenance equipment. Special fume scrubbers ($20,000) are required to reduce hazards and to meet requirements of the Clean Air Standards Act.

Lawrence Berkeley Laboratory .... $ 500

Equipment needs of the electronic engineering group ($130,000) include oscilloscopes, a digitizer, pulse height analyzers, and a UV curing system. Many items in the mechanical department are obsolete, and should be replaced with improved equipment ($100,000), including grinders, drill press, lathes, milling machine, etc. Construction and maintenance division requirements ($150,000) include energy monitoring equipment, emergency generators, a remote TV system, and a remote computer terminal. In addition, replacement of trucks and sedans beyond repair will require $100,000.

Oak Ridge National Laboratory .... $ 1,700

Equipment to meet safety standards ($250,000) includes health physics portable instruments, pulse height analyzer, a fire pumper and improvements to the laboratory communications system. Equipment to insure operating reliability ($300,000) includes new drive assemblies for the bulk shielding reactor, an aerial platform, hydraulic crane, and material hoist. Equipment for the laboratory shops includes a dynamometer, specialized lathes, a gas monitor system, mass spectrometer type lead detector, lathes, milling machine, numerical control turning center, drill press, vacuum pump system, welding equipment and various small tools ($360,000). In the computer category ($350,000), needs include plotting equipment, communications equipment, a test processing computer, magnetic tape equipment and mass storage devices. Replacement of vehicles beyond economic repair will require $200,000. Under the quality assurance program, needs include a helium mass spectrometer, high temperature calibration apparatus, a programmable calculator system, a gamma spectrometer and a logic controller system ($200,000).

Construction Project Data Sheet
(Dollars in thousands, except whole dollars in narrative material)

Division of Physical Research
Washington Headquarters

Research, Development and Demonstration Programs
Basic Energy Sciences

1. Title and Location of Project: Accelerator and reactor improvements and modifications, various locations

2. Project No.: 77-8-a

3. Date A-E Initiated: 1st Quarter FY 1977

3a. Date Physical Construction Starts: 3rd Quarter FY 1977

4. Date Construction Ends: 3rd Quarter FY 1979

5. Previous Cost Estimate:
Date: $ None

6. Current Cost Estimate:
Date: 12/75 $1,300,000

7. Financial Schedule:

Fiscal Year	Obligations	Costs
1977	$ 1,300	$ 200
1978	0	800
1979	0	300

8. Brief Physical Description of Project:
This project provides for additions, modifications, and improvements to research accelerators and reactors, and ancillary experimental facilities. The requested funds are necessary to maintain and improve reliability and efficiency of operations, and to provide new experimental capabilities as required for execution of the planned research program. For example, funds of this type have been utilized to build new beam lines and experimental areas at several accelerator facilities. This has made it possible to run several experiments simultaneously, thus greatly improving the efficiency of accelerator utilization. Facilities which compete for funds requested under this project include, among others, the Clinton P. Anderson Meson Physics Facility, Bevatron/Bevalac, SuperHILAC, Oak Ridge Isochronous Cyclotron and Oak Ridge Electron Linear Accelerator, Bates Linear Accelerator, 88" Cyclotron at Berkeley, High Flux Beam Reactor and Tandem Van de Graaff at Brookhaven, and the Ames Research Reactor.

In view of rapidly changing research requirements, no determination has been made as to the allocation of these funds among the various locations, or as to the subprojects which will be finally selected. In order to assure most efficient utilization of funds, final selection will be made near the beginning of FY 1977, based on programmatic requirements at that time. No significant R&D program is anticipated as a prerequisite for design and construction of the subprojects under consideration.

Listed below are those accelerators and reactors which appear at this time to be leading candidates for the funds requested.

Construction Project Data Sheet - Continued
(Dollars in thousands, except whole dollars in narrative material)

77-8-a Accelerator and reactor improvements and modifications, various locations		Research, Development and Demonstration Programs Basic Energy Sciences

A. Argonne National Laboratory		$ 125
1. Model FN Tandem Van de Graaff	$ 125	
B. Chicago Operations Office		270
1. Bates Linear Accelerator	270	
C. Lawrence Berkeley Laboratory		430
1. Bevatron/Bevalac	310	
2. SuperHILAC	120	
D. Los Alamos Scientific Laboratory		475
1. Clinton P. Anderson Meson Physics Facility	475	

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

A. Argonne National Laboratory

1. Model FN Tandem Van de Graaff

The accelerator is to be improved by addition of pre-tandem bunching structures, a post-tandem bunch phase detector and feedback controls. In addition, the high voltage terminal will be rebuilt to incorporate a heated foil ion stripping system, a beam focussing element, beam energy controls and a communication link to equipment at ground potential. These changes will improve substantially the tandem's capability to accelerate heavy ions, and to serve as an injector.

B. Chicago Operations Office

1. Bates Linear Accelerator

Two modulators will be converted to accommodate a new type of switchtube. Operation with the new tubes will provide lifetime statistics to guide a future decision on which type of tube would maximize accelerator performance and economy. The higher peak current of the recently developed tube is expected to yield an increase of about 10 percent in accelerator energy.

C. Lawrence Berkeley Laboratory

1. Bevatron/Bevalac

The power supplies for the pole-face windings will be modified to increase the capabilities of the magnetic field correction system, thus improving heavy ion acceleration. To improve reliability and efficiency of the 20 MeV injector linac, the pre-exciter oscillator will be converted into a driven amplifier. A non-destructive beam analysis system will be fabricated to permit continuous monitoring of beam characteristics and more efficient and reliable operation.

Construction Project Data Sheet - Continued
(Dollars in thousands, except whole dollars in narrative material)

77-8-a Accelerator and reactor improvements and modifications, various locations | Research, Development and Demonstration Programs Basic Energy Sciences

2. SuperHILAC
A beam chopper and energy measurement apparatus will be fabricated, enabling the SuperHILAC to provide accurate intermediate and full energy beams with different types of structure, from both injectors on a time-shared basis. A heavy ion duoplasmatron source will be fabricated to make the SuperHILAC capable of meeting the experimental demands for higher intensity light ion beams.

D. Los Alamos Scientific Laboratory
1. Clinton P. Anderson Meson Physics Facility
The LAMPF beam duty factor is limited by the average power capability of the gridded tubes employed in the 201.25 megahertz part of the linac. Their replacement with electromagnetically focused klystrons of high efficiency is necessary in order to increase the duty factor from 6% to about 10-12%. This will also eliminate the most important cause of accelerator downtime, and thus result in improved operational efficiency. The accuracy of many of the experiments performed at LAMPF, which respond to one particle at a time, will also be improved with an increase in the duty factor.

10. Details of Cost Estimate:
See description, Item 8. The estimated costs are preliminary and, in general, indicate the magnitude of each project. These costs include engineering, design, inspection, and contingency allowances.

11. Method of Performance:
Design will be by contractor staff. To the extent feasible, construction and procurement will be accomplished by fixed-price subcontracts awarded on the basis of competitive bidding.

Construction Project Data Sheet
(Dollars in thousands, except whole dollars in narrative material)

Massachusetts Institute of Technology
Chicago Operations Office

Research, Development and Demonstration Programs
Basic Energy Sciences

1. Title and Location of Project: Expanded experimental capabilities, Bates Linear Accelerator, MIT

2. Project No.: 77-8-b

3. Date A-E Initiated: 1st Quarter FY 1977

3a. Date Physical Construction Starts: 1st Quarter FY 1978

4. Date Construction Ends: 2nd Quarter FY 1979

5. Previous Cost Estimate:
Date: $ None

6. Current Cost Estimate:
Date: 12/75 $5,000,000

7. Financial Schedule:

Fiscal Year	Obligations	Costs
1977	$ 5,000	$ 900
1978	0	2,700
1979	0	1,400

8. Brief Physical Description of Project:
This project will provide a second experimental hall together with a supporting data acquisition and control building, and an addition to the existing lab-office building to house laboratories, offices, shops, and an equipment assembly area.

As presently conceived, the experimental hall would be approximately 15,300 sq. ft. gross area with 4 feet to 10 feet thick walls and 4 feet thick roof; all of reinforced concrete, covered with earth fill of approximately 9 feet thick. The hall will have a high bay area of approximately 7,700 sq. ft. net area and 40 feet clear height, served by a 45 ton bridge crane; and a smaller high bay area of approximately 15 feet clear height and 3,000 sq. ft. net area, served by a 10 ton bridge crane.

The data assembly and control building will be constructed of masonry or steel frame adjacent to the experimental hall. It will be approximately 2,460 sq. ft. gross area and will be connected to the experimental hall and the existing lab-office building by combination utility-pedestrian tunnels. The addition to the lab-office building will be approximately 9,600 sq. ft. gross area of which approximately one third will be single story high bay space (23 feet high) served by a 20 ton bridge crane, and approximately two thirds will be a two story lab-office extension. Both will be of masonry construction on steel frame.

Sitework will include a paved parking area and gravel access road (9,500 sq. ft.), a concrete paved experimental yard (15,000 sq. ft.), and an earth berm for added shielding of approximately 10,000 cu. yds. Utilities will be extended from existing plant services.

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

The deployment and utilization of important secondary sources of photons, neutrons, pions and muons require a second experimental area. With the high intensity and duty factor of this machine, a research program of much greater breadth will be implemented. At the time of initial construction of this facility, the National Science Foundation had also planned to establish a major electron accelerator facility at Stanford University. However as a result of difficulties experienced in the accelerator technology which was to be adopted, the National Science Foundation no longer plans to proceed with establishing the facility. Therefore, the potential capability of the Bates accelerator for electronuclear physics is unique in the United States and only one other facility in the world (Saclay, France) is comparable. Within the past few years, a number of universities and institutions have shown definite interest in doing research with the facility. Potential users have expressed strong intent to implement experiments at the earliest possible opportunity consistent with the extent and adaptability of facilities. Both the range of experimental possibilities and the ability to respond significantly to user requirements for independent original research make essential the construction of this separate general purpose experimental area.

The current lack of space at the facility is a significant impediment to efficient research operations. Six trailers are in use as office space, which is possible only because a temporary variance to city ordinances has been granted. The current limited shielding around the Spectrometer Room will make operations with beams of varying intensities difficult, in that more expensive portable shielding will have to be moved around for different beam set-ups. The additional earth shielding will minimize down-time and permit greater flexibility in experiments. No significant R&D prerequisite to the design and construction is requested and increased operating costs are expected to be minimal.

10. Details of Cost Estimate*

		Item Cost	Total Cost
a. Engineering, design and inspection costs @ approximately 20% of construction costs, Item b			$ 650
b. Construction Costs			3,340
(1) Improvements to land, site development, walks, roads, earth shielding, etc.		$ 170	
(2) Buildings**		2,180	
(a) Experimental Hall, approximately 15,300 sq. ft. @ about $93/sq. ft.	$ 1,420		
(b) Data Assembly and Control Bldg., approximately 2,460 sq. ft. @ about $81/sq. ft.	200		
(c) Laboratory and Utility Buildings approximately 9,600 sq. ft. @ about $56/sq. ft.	560		

*Based on completed conceptual design.

**Relatively high unit cost is due to requirements for thick reinforced concrete construction and higher than normal roof.

Construction Project Data Sheet - Continued
(Dollars in thousands, except whole dollars in narrative material)

77-8-b Expanded experimental capabilities, Bates Linear Accelerator, MIT | Research, Development and Demonstration Programs
Basic Energy Sciences

	Item Cost	Total Cost
(3) Other Structures - passageway and pumphouse	$ 80	$
(4) Special Facilities (beam transport system, etc.)	790	
(5) Utilities, water, sewer, electric, etc.	120	
c. Standard Equipment		370
Subtotal		4,360
d. Contingency @ approximately 15% of above costs		640
Total Project Cost		$ 5,000

11. Method of Performance:
Design and inspection will be on the basis of a negotiated architect-engineer contract. To the extent feasible, construction and procurement will be accomplished by fixed-price contracts and subcontracts awarded on the basis of competitive bidding.

Construction Project Data Sheet
(Dollars in thousands, except whole dollars in narrative material)

Brookhaven
National Laboratory

Research, Development and Demonstration Programs
Basic Energy Sciences

1. Title and Location of Project: Increased flux, high flux beam reactor (HFBR), Brookhaven National Laboratory, New York

2. Project No.: 77-8-c

3. Date A-E Initiated: 1st Quarter FY 1977

3a. Date Physical Construction Starts: 2nd Quarter FY 1977

4. Date Construction Ends: 2nd Quarter FY 1979

5. Previous Cost Estimate:
Date: $ None

6. Current Cost Estimate:
Date: 12/75 $2,500,000

7. Financial Schedule:

Fiscal Year	Obligations	Costs
1977	$ 2,500	$ 450
1978	0	1,260
1979	0	790

8. Brief Physical Description of Project:
This project provides for the modification of the HFBR to permit operation at 60 megawatts (Mw), an increase of 50 percent above the current operating level of 40 Mw which will increase the neutron flux by the same amount. The principal modification required is the replacement of the two primary heat exchangers with larger ones. Minor changes are needed to augment the secondary cooling water and emergency cooling systems and to re-range instrumentation systems. The new heat exchangers will have an approximate increase of 50 percent in heat transfer area, thus the volume of water required to fill the heat exchangers, on both the primary and secondary sides will also be larger. Since the primary side fluid is heavy water (D_2^0), the additional amount required is treated as a project cost item. The reactor proper requires no further shielding for 60 Mw operation. The installation of the heat exchangers will control the estimated reactor downtime of two months. Therefore, a major goal will be to prefabricate, preinspect and test, so as to minimize reactor downtime.

Modifications to the emergency cooling system are necessary, because recently conducted laboratory tests indicate that some core overheating may occur during the flow reversal period which follows emergency shutdown from 60 Mw. The modifications being proposed will delay the onset of flow reversal until the danger of overheating no longer exists. The remainder of the construction will be in the cooling tower system. This will necessitate enlarging one of the two sumps, some pipe modifications and the enlargement of one of the filter flumes.

Construction Project Data Sheet - Continued
(Dollars in thousands, except whole dollars in narrative material)

77-8-c Increased flux, high flux beam reactor (HFBR) — Research, Development and Demonstration Program
Brookhaven National Laboratory, New York — Basic Energy Sciences

9. Purpose, Justification of Need for and Scope of Project:
The HFBR has proven to be a highly successful reactor both in achieving its original design objectives and as an important research facility. As a result, Brookhaven scientists and users from universities have been able to undertake forefront investigations which could not be considered on a practical basis at any other laboratory. With new high flux research reactors abroad, however, our position is being challenged. The French-German reactor at Grenoble, in particular, now in full power, is designed to provide a maximum thermal neutron flux twice as high as that of the HFBR, and under experimental low background conditions comparable to the HFBR. The proposed power increase for the HFBR is required in order to permit work on new experiments which are either marginally feasible at present, or require so much reactor time as to create severe scheduling problems. Definitive work on anharmonicity effects on phonon lifetimes, for example, has been greatly limited by available intensities. The pioneering work at Brookhaven in "dynamic crystallography", has opened up a new field of far-reaching significance in solid state physics, but its exploitation is restricted at present to very simple cases. Many problems, especially those involving use of separated isotopes in short supply, are sample-size-limited. The reason little real progress has been made on the liquid state, especially with regard to dynamical properties, has been largely that of inadequate neutron intensities for beam experiments. The new Cold Neutron Moderator will represent a significant enlargement in scope for the overall research program at the HFBR. However, among the many new types of experiments made possible by this important new facility, some in the wavelength range of greatest potential interest will be only marginally feasible. Finally, experiments at Brookhaven have demonstrated that neutron scattering can provide a powerful tool in protein crystallography, and some striking improvements in instrumentation and techniques for such work are now under development. Nevertheless, these experiments will require a great deal of reactor time. Therefore, an increase in beam intensity can be translated directly into either time-saving on one of these important experiments, or an enlargement of its scope. No significant R&D program is anticipated as a prerequisite for design and construction of this project. The increase in reactor operating costs as a result of this modification is estimated at $200,000 per year.

10. Details of Cost Estimate*

		Item Cost	Total Cost
a. Engineering, design and inspection costs at approximately 15% of item b, construction costs			$ 210
b. Construction Costs			1,420
(1) Improvements to land		$ 0	
(2) Building		0	
(3) Other structures (cooling tower modifications)		100	
(4) Special facilities		1,320	
(a) Heat exchanger installation, including process piping and reactor instrumentation changes	$ 120		

*Based on completed conceptual design.

Construction Project Data Sheet - Continued
(Dollars in thousands, except whole dollars in narrative material)

77-8-c Increased flux, high flux beam reactor (HFBR)
Brookhaven National Laboratory, New York

Research, Development and Demonstration Program
Basic Energy Sciences

		Item Cost	Total Cost
(b) Procurement of two heat exchangers, including required engineering and special fabrication to fit existing cell	1,190		
(c) Procurement, installation and testing of DC motors and battery supply	10		
c. Standard Equipment			0
d. Heavy Water - 14,000 lbs.			550
Subtotal			2,180
e. Contingency @ approximately 15% of above costs			320
Total Project Cost			$ 2,500

11. Method of Performance:
Design will be by the operating contractor. Construction and procurement will be accomplished by fixed-price subcontracts awarded on the basis of competitive bidding.

Construction Project Data Sheet
(Dollars in thousands, except whole dollars in narrative material)

Oak Ridge National Laboratory

Research, Development and Demonstration Programs
Basic Energy Sciences

1. Title and Location of Project: Conversion of steam plant facilities, Oak Ridge National Laboratory, Tennessee

2. Project No.: 77-8-d

3. Date A-E Initiated: 1st Quarter FY 1977

3a. Date Physical Construction Starts: 3rd Quarter FY 1977

4. Date Construction Ends: 4th Quarter FY 1979

5. Previous Cost Estimate: Date: $ None

6. Current Cost Estimate: Date: 12/75 $12,200,000

7. Financial Schedule:

Fiscal Year	Obligations	Costs
1977	$ 12,200	$ 1,000
1978	0	7,900
1979	0	3,300

8. Brief Physical Description of Project:
Steam requirements at Oak Ridge National Laboratory are supplied from five gas-oil fired boilers having a combined rated steam production capacity of 300,000 pounds per hour. The central steam plant facilities constructed in 1947 consisted of three coal-fired boilers with auxiliary equipment. These units were converted in 1950 from coal to gas-oil firing, and the coal handling equipment was removed. Two additional gas-oil fired boilers were installed in 1956 and 1963 respectively. The proposed conversion of four of the units to coal-oil firing will require alterations and additions to the existing steam plant facilities including the installation of stokers, grates, electrostatic precipitators, draft fans, and coal and ash handling equipment; the construction of coal yard facilities and a control room; modifications to existing stack breeching for the installation of the precipitators; and upgrading the electrical systems to handle the increased power loads. A fifth boiler unit was designed specifically for gas-oil firing and cannot be altered for coal-oil service. A steam line (approximately 1-1/2 miles in length) will be extended to the shops, stores, and warehouse area, because the heating for the buildings will be changed from gas-fired unit heaters to steam-coil space units. An automatic sprinkler fire protection system will be installed in the steam plant building to conform to existing code requirements.

9. Purpose, Justification of Need for and Scope of Project:
The impending shortages of both gas and oil for fuels, plus government policies aimed at curtailment of these fuels for steam production, precipitates the need for immediate action to provide funds for the conversion of existing facilities to fossil fuel for the production of steam. Temporary additional oil storage capability was installed at the laboratory to provide a reserve fuel capacity for approximately three weeks. Based on the limited storage capacity, an interruption of oil supply would result in severe curtailment and possibly complete shutdown of the Laboratory's operations. Approximately

ninety percent of the total steam produced is used for essential heating and operating purposes, while the remaining ten percent is for heating low-priority buildings which could be placed on an as-needed schedule to prevent freezing of sprinkler systems or stored materials.

The shops, warehouse, and stores area facilities use gas-fired unit heaters during the heating season. During the heating season of 1974-1975, the gas supply was completely shut off to that area about eighty percent of the time, forcing the use of portable oil-fired heaters on limited and selective basis. These units were not permitted in buildings having high risk values, such as paint shops and in storage areas containing flammable materials.

10. Details of Cost Estimate*

		Item Cost	Total Cost
a. Engineering, design, and inspection at 15% of construction costs, item b			$ 1,320
b. Construction costs			8,880
(1) Improvements to land		$ 180	
(2) Building Modifications		90	
(3) Utilities		8,610	
(a) Conversion of existing boilers	$ 7,110		
(b) Steam line and heating units conversion	1,500		
c. Standard equipment			0
Subtotal			10,200
d. Contingency at approximately 20% of above costs			2,000
Total Project Cost			$ 12,200

*Based on completed conceptual design

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

Congressional Submission
FY 1977

Construction Project Data Sheet
(Dollars in thousands, except whole dollars in narrative material)

Division of Physical Research

Research, Development and Demonstration Programs
Basic Energy Sciences

1. Title and Location of Project: General plant projects
2. Project No.: 77-14
3. Date A-E Initiated: 1st Quarter FY 1977
3a. Date Physical Construction Starts: 2nd Quarter FY 1977
4. Date Construction Ends: 2nd Quarter FY 1979
5. Previous Cost Estimate: Date: $ None
6. Current Cost Estimate: Date: 12/75 $ 7,300,000

7. Financial Schedule:

Fiscal Year	Obligations	Costs FY 1975	FY 1976	Transition Period	FY 1977	After FY 1977
Prior Year Projects	$ xxx	$ 1,663	$ 708	$ 0	$ 0	$ 0
FY 1975 Projects	3,750	945	2,034	480	291	0
FY 1976 Projects and Transition Period	4,565	0	650	460	2,190	1,265
FY 1977 Projects	7,300	0	0	0	1,092	6,208
		$ 2,608	$ 3,392	$ 940	$ 3,573	$ 7,473

8. Brief Physical Description of Project:
This project is required to provide for minor new construction, other capital alterations and additions, and for retirements to land, buildings and utility systems. Where applicable, the request also includes the cost of installed capital equipment integral to a subproject. Funding of this type is essential for maintaining the productivity and usefulness of ERDA-owned facilities. Since it is difficult to detail this type of project in advance, a continuing evaluation of requirements and priorities may be expected to result in additions, deletions, and changes to the currently planned subprojects. In general, the estimated funding for each location is preliminary in nature, and is intended primarily to indicate the relative magnitude of the requirements. $4,000,000 is for a special Lawrence Berkeley Laboratory requirement to correct fire, earthquake and safety hazards in order to meet ERDA improved risk criteria. No significant R&D program is anticipated as a prerequisite for design and construction of the subprojects under consideration.

The funds requested for FY 1977 are estimated as follows:

Ames Laboratory	$ 250
Lawrence Berkeley Laboratory	4,000
Los Alamos Scientific Laboratory	200

Construction Project Data Sheet - Continued
(Dollars in thousands, except whole dollars in narrative material)

77-14 General plant projects

Research, Development and Demonstration Programs
Basic Energy Sciences

	FY 1977
Notre Dame Radiation Laboratory	$ 10
Massachusetts Institute of Technology	90
Cak Ridge National Laboratory	2,650
Washington - Division of Physical Research	100
Total Project Cost	$ 7,300

9. Purpose, Justification of Need for and Scope of Project:
Following are examples of the major items of work to be performed at the various locations:

Ames Laboratory .... $ 250
In the reactor building, a system will be fabricated to collect and utilize waste heat from the reactor, thus reducing energy consumption by about 10%. Also, a small chiller will be added for equipment cooling to permit deactivation of the water cooling towers during the winter ($90,000). To assure reliable reactor operation, the 19 year old electric power conversion system must be replaced with a solid-state uninterruptible power supply ($160,000).

Lawrence Berkeley Laboratory 4,000
$4,000,000 is required to carry out high priority fire, earthquake and safety hazard corrections, as required to meet improved risk criteria. This includes construction of two new 200,000 gallon water storage reservoirs and installation of two 1,500 gpm diesel engine pumps, all as an integral part of the Laboratory water distribution grid ($650,000), installation of automatic fire suppression systems in twenty-seven (27) existing buildings ($1,800,000) structural strengthening of five (5) buildings to prevent possible collapse during a strong earthquake to promote life safety for personnel and for protection of property ($1,000,000), construction of new firehouse of approximately 5,500 gross square feet to replace the existing facilities ($480,000), and construction of a sprinkler-protected building of approximately 1,260 gross square feet in the vicinity of the External Proton Beam Hall, to provide storage for combustibles such as oil drums, flammable gas cylinders, coils of insulated cable and wood pallets and cribbing ($70,000).

Los Alamos Scientific Laboratory 200
Requirements include modifications to buildings and utilities to meet experimental program needs ($200,000).

Notre Dame Radiation Laboratory 10
This project provides for modifications to the Radiation Research Building at the University of Notre Dame. Changes in the method of pursuing the research program necessitate some minor modifications and improvements for smooth and efficient operations.

Masschusetts Institute of Technology .... $ 90
This request will provide for a concrete and earthen enclosure to house the high power spectrometer beam dump, which is required for parasitic beam studies and the new 180° scattering beam.

Oak Ridge National Laboratory 2,650
Requirements include a new hot off-gas line for the Isotopes Division to replace an old line which has developed leaks ($200,000), a 200-300 ton cooling water system to meet requirements of the CTR program superconducting magnet development work ($300,000), facilities at the Transuranium Processing Plant to reduce the volume and actinide content of contaminated solid waste ($480,000), three modular office buildings are required to provide space for new energy research programs ($300,000 each), an extension to the building 7108 warehouse to permit centralization of salvage and excessing activities ($400,000), fire protection improvements, primarily sprinkler systems, in 17 buildings to meet improved risk criteria ($200,000), and replacement of 480-volt switchgear in part of building 9210, which does not meet operational or safety requirements ($100,000).

Washington - Division of Physical Research 100
Under the off-site program, a number of contractors are using very large facilities such as reactors, cyclotrons, synchrotrons and other particle accelerators. These facilities require the same type of modifications and additions as ERDA's laboratories in order to keep abreast of the progress in their research programs. The funds in this project are required to permit better utilization of these services and facilities.

10. Details of Cost Estimate:
Not available at this time.

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