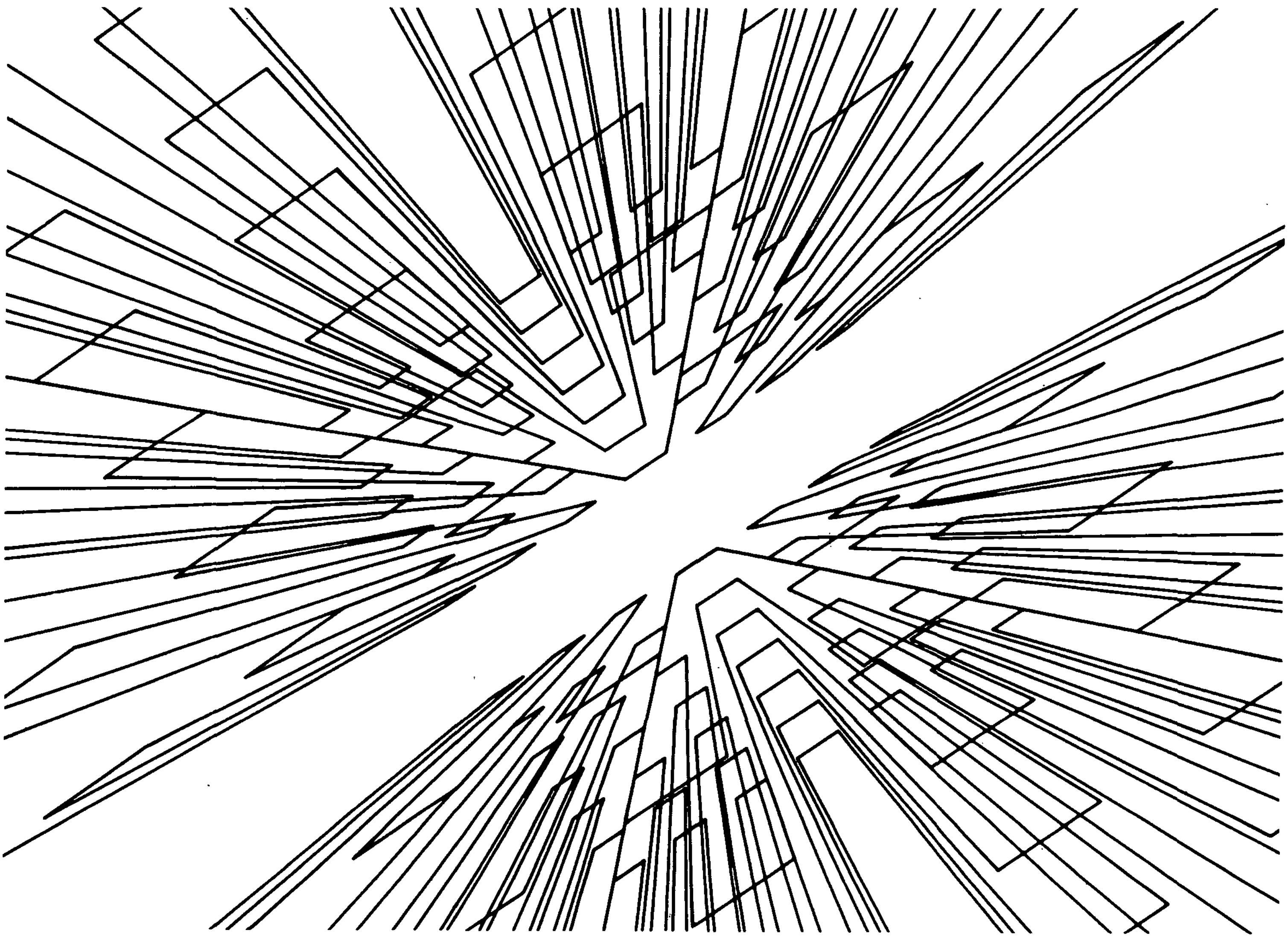
October 1982 U.S. Department of Energy DOE/ER-0146

Office of Basic Energy Sciences

1982 Summary Report



The Office of Basic Energy Sciences is one of several program offices in the Department of Energy's Office of Energy Research and plays an important role in the support of basic research in the United States today. The program is strongly oriented toward developing the information and understanding required for the long-term technological capability of the nation. This program is organized along the disciplinary lines of research science to effectively interact with the scientific community. The program summaries that describe the BES subprograms are also organized by scientific disciplines, but the basic research conducted under the auspices of several of our divisions often has a common underlying energy theme. A survey of research activities relevant to improving our insight into problems and solutions of long-term nuclear waste isolation, for instance, will span several disciplines. Conversely, a given project can impact more than one energy technology; this illustrates the merits of basic research.

This report is a summary document on the Basic Energy Sciences program, its overall scope, the kinds of activities carried out, and the unique facilities that have become a key part of our ability to conduct forefront research.

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Office of Basic Energy Sciences

1982 Summary Report

A summary of the organization, mission, and activities of the Office of Basic Energy Sciences

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Introduction

Over the years the United States has developed a tradition of leadership in science and technology which has made us a model for developing nations throughout the world. All our national goals—better health and quality of life for all our people, vigorous economic growth, energy self-sufficiency, national security, space exploration, etc.—involve technological advances that depend on basic research. The principal product of this research is knowledge, the foundation on which new ideas and concepts can take shape and on which important decisions can be made.

Basic research is a high-risk activity, however, requiring long-term commitments and large sums of money with no promise of obvious success or early returns on investments. Consequently, the private sector has little incentive to support it. But the foundations must be laid.

For example, for many years the federal government, through various funding agencies, including the Department of Energy and its predecessor organizations, has supported basic research in the quantum theory of solids, transport phenomena in conductors and semiconductors, optical properties of such materials, and basic chemistry and electrochemistry of polymers. It was not until very recently that, on the basis of general knowledge gained in such research, an application of conducting polymers was identified which can profoundly influence energy-related technology. Batteries, both storage and primary, using thin sheets of properly doped polyacetylene as electrodes, have now been demonstrated in a laboratory and may very well be developed into products by the industry. At this time prospects for commercialization are still uncertain, but the example illustrates how vital basic research is to continued technological innovation.

Thus basic research becomes the proper role and the responsibility of the federal government as the only agency with the motivation, capability, and continuity to carry it through.

This booklet briefly describes the program of the Office of Basic Energy Sciences of the Department of Energy, which is responsible for basic research in the field of energy. Its subprograms and facilities are discussed, along with an abbreviated budget summary and an outline of plans for the future. Reports referenced are normally available from the National Technical Information Service, U. S. Department of Commerce, Springfield, VA 22161.

Overview

The Office of Basic Energy Sciences (BES), which reports to the Department of Energy's (DOE) Director of Energy Research, is the office responsible for long-range basic energy-related research and is charged with providing the fundamental scientific foundation on which the nation's future energy options depend. The organization of BES, which is primarily discipline oriented, is shown in Fig. 1. Research is sponsored in selected areas of the traditional scientific disciplines—the physical and biological sciences, geosciences, engineering, and mathematics. The subprograms of BES support approximately 1200 individual research projects, each one selected on the basis of its scientific merit, its possible relevance to meeting the BES long-range research goals, and its contribution toward a balanced, responsive research program.

The knowledge that results from BES-sponsored research becomes a part of the body of information on which the applied technologies rest. Although research to broaden the technology base needed for identified energy options is extremely important, even more important is the need for basic research, unfettered by preconceived notions of what technologies will be important several decades from now, so that new, not yet identified options may emerge. Because of its diversified interests, with centralized management and common goals, BES can respond quickly and efficiently to DOE and national missions. The scientists and engineers of BES include professionals with years of experience in fostering and conducting creative basic research and managing major complex research facilities.

Any discussion of BES must consider that:

• BES is oriented toward DOE's energy mission.
• BES is a major participant in the physical and engineering sciences efforts of the nation.
• BES is a principal source of support of university research and of the national laboratories.
• BES is involved in the construction and operation of large and complex scientific facilities.

The energy supply and conservation missions of DOE are so vital to the nation's future that a comprehensive program of basic energy-related research is essential. It is the responsibility of BES to plan and administer DOE's program of basic research in the physical, biological, and engineering sciences exclusive of high-energy and nuclear physics and the medical and environmental sciences. The multipurpose national laboratories are national assets and play an essential role in U. S. science and technology, maintaining excellent, productive scientific and engineering staffs, building and operating complex scientific facilities, and undertaking large interdisciplinary projects. A large fraction of the BES budget goes to the national laboratories to support research, much of it dependent on complex facilities and services at the laboratories.

Basic Energy Sciences has a heavy involvement in scientific facilities (e.g., the National Synchrotron Light Source at Brookhaven National Laboratory, the Combustion Research Facility at Sandia-Livermore, the High Flux Isotope Reactor at Oak Ridge National Laboratory, and high-voltage and atomic resolution microscopes). Many areas of modern science require large and costly facilities; without them the necessary research could not be done. The large, expensive, unique facilities in the BES program are made available to the entire basic research scientific community to the extent that funds permit the additional shifts of operation.

Most of the scientists involved in BES research programs are at universities and national laboratories. University research receives support in several ways, e.g., "financial plan" funding, in which rather large sums of money are allocated to institutions to support identified projects but the institution is delegated authority to manage the overall program of research; special research contracts (and, in the future, grants) to support the research of individual scientists with graduate assistants, which is the largest form of university support; and support of two national laboratories that are co-

Figure 1 Office of Basic Energy Sciences organizational chart.

Office of the Associate Director
R. H. Kropschot
Deputy Associate Director
D. K. Stevens

Division of Materials Sciences
L. C. Ianniello

Division of Chemical Sciences
E. S. Pierce

Division of Eng., Mathematical, and Geosciences
J. S. Coleman

Division of Carbon Dioxide Research
F. Koomanoff

Division of Advanced Energy Projects
R. Gajewski

Division of Biological Energy Research
R. Rabson

located with universities—Lawrence Berkeley Laboratory at the University of California and Ames Laboratory at Iowa State University. In addition, free access by qualified scientists is provided to user facilities at national laboratories. More than one-third of BES funding supports university-based research. An important fringe benefit resulting from supporting research in universities is the research training of graduate students who continue in R&D after completion of their studies.

In addition to universities and national laboratories, BES maintains ties with industry. Representatives of appropriate industries serve on counseling committees for several of the BES subprograms; experts from industry participate in the review of research proposals and use the specialized facilities sponsored by BES; industrial scientists participate in program advisory committees at the national laboratories; and industry representatives are invited to attend the BES conferences and workshops. Through these and other mechanisms available to and used by the scientific community, the results of the BES program are available to industry and to the academic community.

The Office of Basic Energy Sciences evolved from the Division of Physical Research of the Atomic Energy Commission. The Office expanded its activities with the formation of the Energy Research and Development Administration in 1975 and again with the establishment of DOE in 1977. Each transition broadened the scope of its responsibilities for research in energy technologies, e.g., from nuclear to fossil, solar, and conservation. For over 35 years, BES has responded to the needs for basic research in areas of national priority.

Research in BES is conducted under seven subprograms: Materials Sciences; Chemical Sciences; Nuclear Sciences; Engineering, Mathematical, and Geosciences; Advanced Energy Projects; Biological Energy Research; and Carbon Dioxide Research. At present, programmatic priorities call for emphasis in the areas of Biological Energy Research, Advanced Energy Projects, and Engineering, Mathematical, and Geosciences. Other areas currently being emphasized include:

- High-temperature materials—corrosion, ceramics, and coatings
- Synthesis of novel materials
- Chemistry and physics of combustion processes
- Surface modification
- High-voltage and atomic resolution microscopy
- Condensed matter theory
- Amorphous materials
- Chemical structure and behavior of coal
- Structural ceramics
- Synchrotron radiation research
- Catalytic mechanisms and surface phenomena
- Neutron scattering research
- Photochemistry
- Nuclear data for fusion reactions
- Nondestructive evaluation

Each of the subprograms is described briefly in the following chapter. The major objective of BES—to provide the basic scientific knowledge and insight necessary to develop new and improved energy options—is pursued through several concurrent approaches, some already identified. They are to:

- Provide critical knowledge and data and develop trained scientific talent through support of highly competent researchers in DOE mission areas
- Provide for and support the operation of unique, specialized research facilities
- Maintain liaison with other DOE programs, federal agencies, and the scientific, academic, and industrial communities
- Seek the scientific and industrial communities' identification of needs and opportunities for research in areas likely to be relevant to future energy options
- Expand research into new areas identified as having potential importance to energy
- Promote application of the results of basic research

Interagency information exchanges, committee interactions, and workshops provide useful liaison between BES and other research groups. For example, DOE offices and laboratories and such federal agencies as the National Science Foundation, the Nuclear Regulatory Commission, and the U. S. Geological Survey have working groups and committees that routinely exchange information and coordinate program activities in such common research areas as nuclear data, chemistry, geophysics, hydrogen, materials, and combustion research. Coordinating committees discuss individual proposals and compare work being done by the various agencies to avoid overlap and duplication of effort. Outreach workshops and working groups bring together investigators in related areas to share information and discuss problem areas in their work. Finally, and of most importance, study results always are published in the open literature to make them available to the scientific community worldwide.

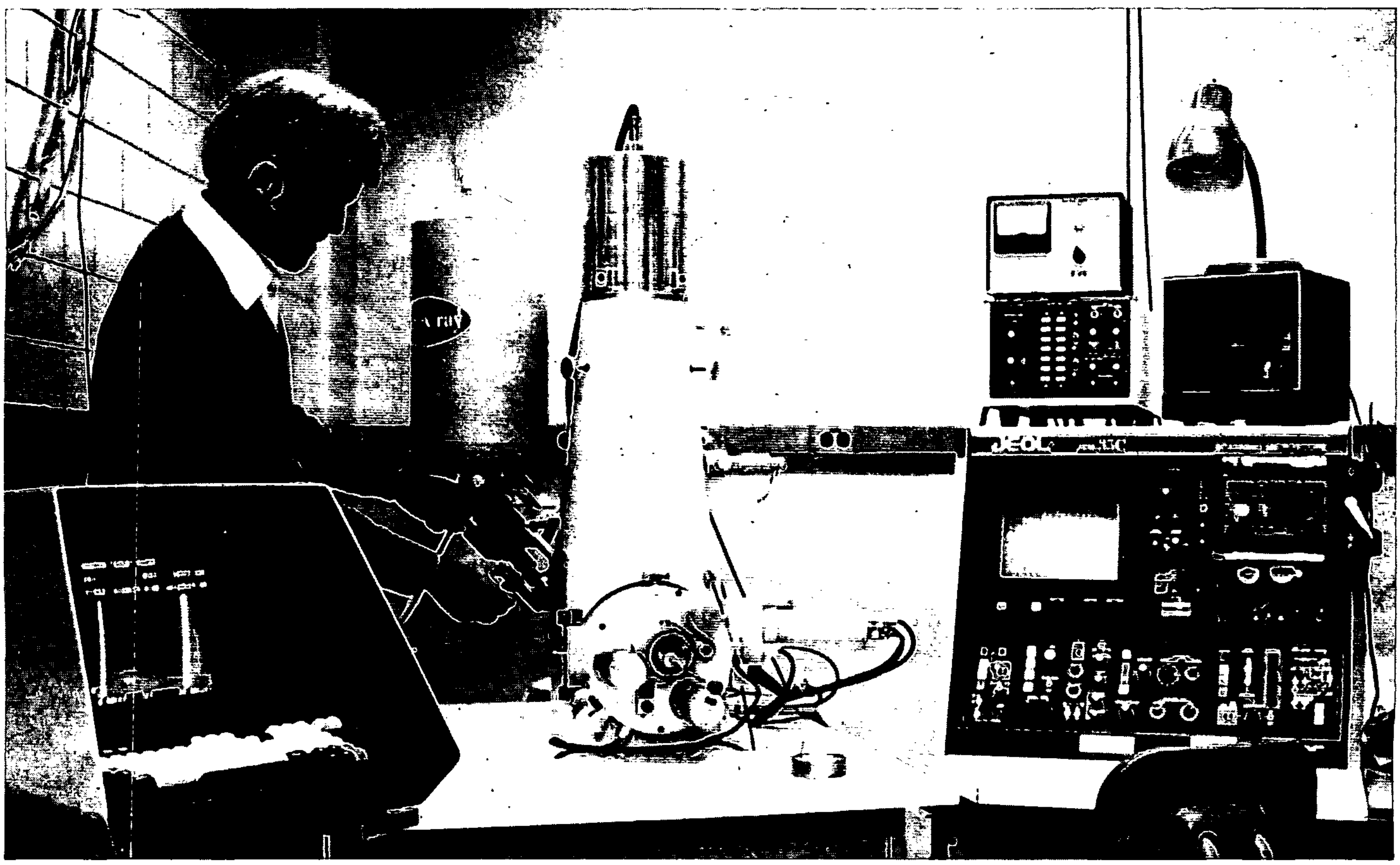
Subprograms

Materials Sciences

The goal of the Materials Sciences subprogram is to increase understanding of the phenomena and properties important to materials behavior; this understanding is essential to the development of future energy technologies. It is well-known that materials problems and limitations often restrict the performance of current energy systems and the development of future systems. Some needs to which Materials Sciences research ultimately contributes include:

- Developing new or substitute materials
- Tailoring materials to satisfy defined requirements
- Predicting materials problems and service life
- Improving the ability to successfully attack unforeseen materials problems in advanced energy systems
- Improving the theoretical and experimental capability to analyze the fundamental structure of materials

With support at a level of $104 million in FY 1982, BES's Materials Sciences subprogram provides about one-third of the total federal funding for basic materials research. Materials Sciences places emphasis on selected generic areas of fundamental importance and on areas where problems are known to exist or are anticipated. Some research is directed at a single energy technology (e.g., photovoltaic materials for solar energy conversion); some research has applicability to many technologies simultaneously (e.g., embrittlement of structural materials in the presence of hydrogen); and still other research has more fundamental implications underpinning all materials research (e.g., mechanisms of atomic transport in solids). The research is conducted in a variety of institutions—DOE laboratories, universities, and, to a lesser extent, industrial installations—and uses the talents



of metallurgists, ceramicists, solid-state physicists, and materials chemists.

In addition to maintaining an appropriate mix of long-term scientific multitechnology and single-energy-technology-related research, a balance must be retained among forefront, large, facility-related research and small individual projects. The Materials Sciences subprogram uses some major facilities in the pursuit of its research goals, including the National Synchrotron Light Source and the High Flux Beam Reactor (HFBR), both at Brookhaven National Laboratory; the Ion Implantation Facility and High Flux Isotope Reactor at Oak Ridge National Laboratory; Intense Pulsed Neutron Source at Argonne National Laboratory; and the high-voltage electron microscopes at Oak Ridge, Argonne, and Lawrence Berkeley Laboratories. The operation of these facilities requires about 17% of the operating budget of the Materials Sciences subprogram, not including the research associated with them. Most of these facilities are unique, as is the research carried out at them. The facilities are also available to qualified users outside the DOE laboratory complex.

The agency's materials program is coordinated primarily through the DOE Energy Materials Coordinating Committee. The Materials Sciences subprogram is the basic materials program in DOE, which underpins the energy materials technologies. It represents about 20% of the total DOE materials research and development effort. The fact that there is four times as much effort in applied materials development is testimony to the crucial role materials play in the development of energy systems. Within the federal government, the subprogram is coordinated in part through the interagency Committee on Materials (COMAT). The workshops and reports of the subprogram's Council on Materials Science (a nongovernmental body with representatives from academia, industry, and agency laboratories) help to focus attention on critical issues. In 1982, two panel meetings—on materials research at high pressure and on nuclear waste isolation—were held. The agency's applied materials research workers interact and exchange information through a number of mechanisms, including a formalized Research Assistance Task Force.

Current emphases and trends are toward greater use of the major facilities.

More detailed information on this subprogram can be obtained from Louis C. Ianniello, Director, Division of Materials Sciences, Office of Basic Energy Sciences, Department of Energy, Washington, DC 20545. A detailed summary of current projects is published annually. The most recent (September 1982) is entitled *Materials Sciences Programs, Fiscal Year 1982* (DOE/ER-0143).

Chemical Sciences

The research activities supported by the Chemical Sciences subprogram range from energy-related phenomena involving liquids, gases, and plasmas to the chemical properties of solids, such as coal, chlorophyll, and catalysts, and the phenomena and behavior of submicroscopic particles, such as molecules, atoms, ions, and electrons.

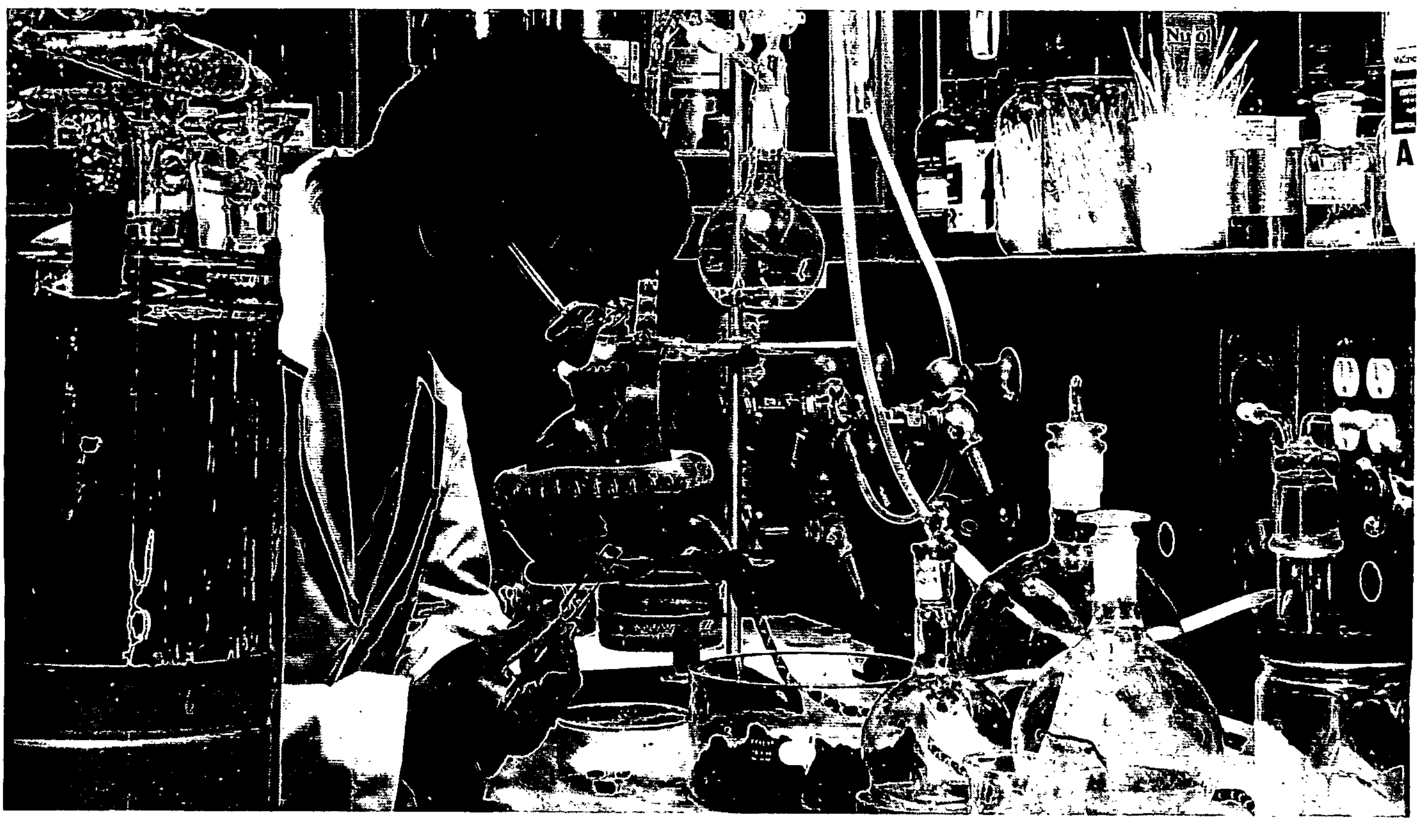
The objective of Chemical Sciences is to expand the knowledge base in the chemical and related sciences in areas most likely to lead to new ideas and improved processes for developing and using domestic energy resources. At a budget level of $68 million, this subprogram is a major source of federal support for basic chemical research in the United States.

Phenomena and processes likely to be important to energy technologists are emphasized in the formulation of the program. Research in some areas, such as the chemical effects of catalysts, may lead to discoveries that can be quickly exploited by industrial process designers; whereas in others, such as water-splitting photochemistry to produce hydrogen, research may not be used for a number of years. Still other research areas, such as studies of radiation emitted by ions moving very fast through crystal foils, produce data for use in developing new energy technologies.

The Chemical Sciences subprogram includes research in the fields of photochemistry, coal chemistry, catalysis, atomic physics of highly charged ions, chemistry basic to nuclear waste separation, biomass conversion of liquid fuels by enzyme catalysis and other methods, energy-efficient separation of valuable metals from low-grade resources, efficient and clean combustion of various fuels, and detection and measurement of harmful by-products of energy processes. Equally important is the fundamental research into chemical and physical phenomena which has no immediately identifiable related technology. A typical example of such efforts is the study of laser-induced excited states of molecules. Disciplinary areas covered by Chemical Sciences work include physical, organic, and inorganic chemistry; chemical physics; radiation chemistry; thermodynamics; thermophysics; and analytical chemistry.

Much of the Chemical Sciences research centers on the special facilities at DOE's national laboratories—the Combustion Research Facility, National Synchrotron Light Source, electron linear accelerators, ion accelerators, superconducting nuclear magnetic resonance spectrometers, very advanced molecular beam machines, differential speed-of-light fiber optics, etc. In addition to their unique equipment, DOE laboratories provide enhanced opportunities for interactions between basic researchers and research and development teams in related energy technology areas. University laboratories carry out a large part of the remaining work, and a small part takes place in industrial laboratories. Laboratory scientists supported by Chemical Sciences also interact with industrial research workers, such as those in the automotive and petroleum industries.

Coordination with energy technology programs is emphasized. Laboratory-based interactions between the basic researchers in Chemical Sciences and the applied technology teams are assisted by headquarters-based coordination. Various committees—e.g., the Combustion Research Coordinating Panel, the Hydrogen Coordinating Committee, Solar Photochemistry Research Conferences, and Coal Chemistry and Catalysis Research Meetings—identify research needs and opportunities, compare results, and coordinate activities within DOE and with the rest of the scien-



tific community. In addition, Chemical Sciences staff members serve as advisors for energy technology activities and visit and review activities at the DOE national laboratories.

Additional detailed information on the Chemical Sciences subprogram can be obtained from Elliot S. Pierce, Director, Division of Chemical Sciences, Office of Basic Energy Sciences, Department of Energy, Washington, DC 20545. A detailed summary of current projects is published annually. The most recent (September, 1982) is entitled *Summaries of FY 1982 Research in the Chemical Sciences* (DOE/ER-0144).

Nuclear Sciences

The objectives of the BES Nuclear Sciences subprogram are to:

- Measure, compile, and evaluate nuclear data for fission and fusion energy technologies
- Improve knowledge of the chemical and physical properties of the actinide elements
- Assure the availability for research of isotopically enriched samples of the elements
- Operate the Stanford Synchrotron Radiation Laboratory

The fission and fusion energy technologies require nuclear data for optimization of reactor design, analysis of operations and safety of reactor systems, and management of spent fuel materials. The nuclear data activity provides a long-range base of data in support of these technologies. Nuclear data needs are documented in great detail and are regularly updated—for *fission* technology, through the work of the Cross Section Evaluation Working Group of the National Nuclear Data Center (NNDC), and for *fusion* technology, by means of a working group of the U. S. Nuclear Data Committee and DOE's Office of Fusion Energy.

The compilation and evaluation effort is concerned with establishing a data base for neutron-induced nuclear reactions and also with maintaining the Evaluated Nuclear Structure Data File (ENSDF), which encompasses all the information produced worldwide on the level structure and decay properties of nuclei.

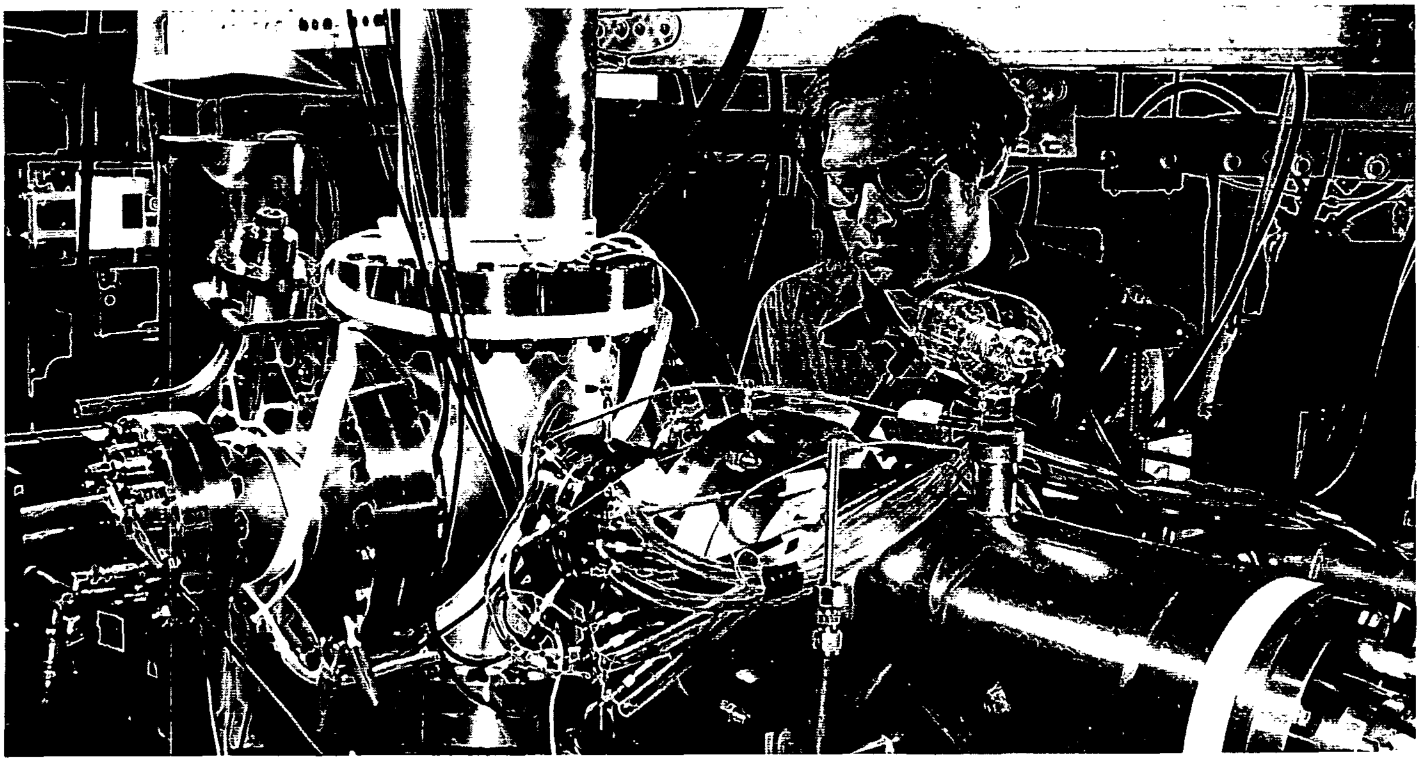
The nuclear data compilation and evaluation effort is centered around the NNDC at Brookhaven National Laboratory, which coordinates a network of scientists performing compilation and evaluation for ENSDF and also coordinates U. S. work with the International Atomic Energy Agency. Data compilation and evaluation activities devoted to ENSDF and the publication of the Nuclear Data Sheets are monitored by an advisory panel of the National Academy of Sciences. Annually, NNDC processes about 700 requests for nuclear data from scientists and engineers in the energy technologies, biomedical scientists, and basic researchers.

The nuclear data measurement effort is centered around the Oak Ridge Electron Linear Accelerator for measurement of neutron cross sections over a wide range of energies. Several small university groups and the National Bureau of Standards collaborate in these activities.

The nuclear energy and technology programs of DOE need specific information and data on the behavior of actinides in fuel processing streams, in nuclear waste hosts materials, and in the environment. Heavy element chemistry research helps meet their needs, as well as contributing to an understanding of the fundamental chemical and physical properties and behavior of matter. These broadly based studies of the actinide elements include behavior in aqueous and nonaqueous solutions, photochemistry, chemical reactivity, spectroscopy, and chemical physics.

Research groups at national laboratories and universities are supported to pursue heavy element (actinide) and radiochemical investigations. The study of actinide chemistry is largely limited to the national laboratories since high levels of radioactivity are involved, but some tracer work is done at universities. These laboratory facilities provide opportunities for visiting scientists from university and foreign labs to pursue collaborative research with the U. S. investigators. The heaviest elements are produced by irradiating curium-loading targets in the High Flux Isotope Reactor (HFIR) and chemically processing the targets in the Transuranium Processing Plant (TRU) to extract and purify the actinide samples. These samples are allocated to investigators engaged in DOE research programs.

Nuclear Sciences also supports the electromagnetic separation of stable isotopes for a Research Materials Collection of samples that are loaned out for nondestructive research in DOE energy technology programs. In addition to its research and information-gathering



activities, Nuclear Sciences is responsible for distributing the stable isotopes and the rare, heavy radioactive isotopes it produces for use in research, medicine, and industry. These efforts constitute the western world's only source of isotopic research samples in significant quantities, and these materials are sold or loaned to institutions throughout the world.

Responsibility for operating the Stanford Synchrotron Radiation Laboratory (SSRL) has recently been transferred to BES. The SSRL was expanded under the auspices of the National Science Foundation in partial response to a National Academy of Sciences report that pointed out the potential for research in the newly identified area of synchrotron radiation. The SSRL, which shares the Stanford Positron Electron Asymmetric Ring with the high-energy physics program, is an important research facility; at present it is heavily oversubscribed by the solid-state, chemical, and biomedical research communities for its high-intensity photons in the ultraviolet and X-ray regions of energy. This is one of two major BES facilities where research of this kind is made possible.

Additional information on the nuclear data activities can be obtained from Enloe Ritter, Director, Division of Nuclear Physics, Office of High Energy and Nuclear Physics, and on the other aspects of the Nuclear Sciences subprogram from Elliot S. Pierce, Director, Division of Chemical Sciences, Office of Basic Energy Sciences, Department of Energy, Washington, DC 20545.

Engineering, Mathematical, and Geosciences

The Engineering, Mathematical, and Geosciences subprogram supports research in mechanical, structural, and electrical engineering; mathematics; statistics; computer sciences; geology; geochemistry; and geophysics. Priorities are established through extensive interaction between experts in technological communities in the fields of interest, building on the well-documented studies of the Energy Research Advisory Board, the agency's comprehensive review of its own technology activities, and studies by the National Academy of Sciences and others.

The objective of engineering research is to advance the engineering science needed for energy production facilities and for increased energy efficiency. At present, three research areas are receiving high priority:

- Mechanical sciences, including tribology (the basic nature of friction-reduction phenomena), heat transfer, and solid mechanics (continuum mechanics and engineering aspects of crack propagation)
- Systems sciences, including process control, instrumentation, and scale-up of process plants
- Engineering analysis, including nonlinear dynamics, thermophysical properties of fluids, and engineering combustion

One of the current projects in tribology provides a useful example of the type of research under way. An attempt is being made to establish a sound experimental basis for a new theory of viscoelastic composites to predict the internal rolling friction of a tire. Automobile efficiency is reduced as a result of the rolling friction of tires—typically 10% or more of the engine horsepower is lost here. Eventually it should be possible to predict the best tire design to maximize fuel mileage without reducing tire life, traction, or safety—the three traditional tire performance criteria.

Engineering research also includes work on instrumentation for measuring basic engineering quantities—temperature, pressure, flow rates, and phase—under extreme conditions of temperature or pressure and efforts to model complex systems to develop predictive capabilities for the scale-up of pilot process plants.

The BES activity in applied mathematical sciences supports approximately 200 mathematicians, statisticians, and computer scientists working on fundamental problems in the development of mathematical models of energy systems. The work is carried out at 30 universities and 10 national laboratories. In areas such as magnetic fusion, nuclear reactors, weapons design, and combustion processes, where experimental tests are difficult, expensive, or even impossible, mathematical models provide the best methods of studying the underlying physical processes. The mathematics program emphasizes three aspects of the modeling process:

- Analytic and computational techniques for formulating and implementing models of energy systems from first principles
- Statistical and computer science techniques for manipulating and analyzing large data bases associated with these models
- Development of algorithms, languages, and architectures for future generations of computers that will be capable of solving more realistic models

The most promising parallel computer architectures are being explored, concentrating on techniques for using hundreds or thousands of inexpensive microcomputers in parallel to solve complex systems of equations at rates ten to a hundred times faster than the best computers available today. A coordinated effort among university, national laboratory, and industry researchers is under way.

The nonlinear dynamics research promises to aid in understanding the nature of turbulence and chaotic motion, which governs reaction rates in combustion processes and plasmas, and coolant flow in reactors.

The objective of the Geosciences program is to develop a quantitative, predictive understanding of the energy-related aspects of geological, geophysical, and geochemical processes both in the earth and at the solar-terrestrial interface.

The Geosciences program is emphasizing (1) long-range research on the geological isolation of nuclear waste, (2) studies in organic geochemistry relating to fossil fuel recovery and the disposition of energy-related chemical waste, and (3) studies of the magma-hydrothermal part of the interagency Continental Scientific Drilling Program.

The effort in nuclear waste isolation addresses unresolved problems with second- and third-generation repositories (e.g., quantitative assessment of local changes of stress, with subsequent development of new fracture systems, which provide pathways for the migration of nuclear wastes; interactions among waste container, rock, and fluids in the rock; and concentrations, diffusion rates, and element migration of nuclear wastes from a disposal site into its surroundings).

The organic geochemical processes of migration, physical changes, and maturation of fossil energy resources are also being studied. Such knowledge is essential if fossil fuels are to be effectively exploited and is required for dealing with the problems of organic wastes.

The Magma Energy Research project, having demonstrated the scientific feasibility of extracting energy from magma bodies, is now being phased out, but the DOE portion of the national Continental Scientific Drilling Program (CSDP) will continue to be focused on magma-hydrothermal systems. A cooperative interagency program, CSDP seeks to develop an understanding of the North American continent. The DOE part will aid in predicting deposits of energy and mineral resources, establishing a scientific base of information relevant to nuclear waste isolation, and assessing hazards associated with the siting of major energy-related facilities. So far several preliminary site assessments have been completed, and a drill-hole data base for holes drilled for the federal government has been established.

Other research involves rock mechanics, geodynamics, advanced geophysical techniques, resource definition and use, and solar-terrestrial relations.

More information on this subprogram can be obtained from James S. Coleman, Director, Division of Engineering, Mathematical, and Geosciences, Office of Basic Energy Sciences, Department of Energy, Washington, DC 20545.

There are three reports available which supply more detailed information on this subprogram:

Summaries of FY 1981 Engineering Research, DOE/ER-0121, February 1982

Summaries of the FY 1981 Applied Mathematical Sciences Research Program, DOE/ER-0115, December 1981

Summaries of Physical Research in the Geosciences, DOE/ER-0109, October 1981

Advanced Energy Projects

The objective of the Advanced Energy Projects (AEP) subprogram is to explore the feasibility of novel energy-related concepts evolving from basic research which are at an early stage of scientific definition and, therefore, would not be of interest to technology programs. To qualify for AEP support, such concepts, even though they involve a high degree of risk, must have the potential for an eventual high payoff. Advanced Energy Projects also sponsors exploratory research on concepts that do not fit easily into the existing DOE program structure. An area of major attention is the transfer of successful projects to technology programs; a number of such transfers have already been made.

A relatively new BES subprogram, Advanced Energy Projects supports individual projects for a limited time only, with the goal of supporting about 20 new projects each year. It differs from other subprograms in that it does not fund ongoing, evolutionary research. After a period of concentrated effort, typically about 3 years, the concept is expected to have proved itself, in which case the basic research phase is completed and the project can be transferred to a technology program. If a successful conclusion to the research is not foreseeable, the project is dropped. Projects are selected from unsolicited proposals received from researchers at universities, industrial laboratories (especially small R&D companies), and national laboratories. Currently, 36 projects are being supported; this allows a turnover rate of about 12 projects per year.

Advanced Energy Projects is an interdisciplinary program whose projects cover a broad technological spectrum, e.g., new approaches to uranium retrieval and separation, completely new methods of solar energy concentration and collection, ultrasonic coal grinding, new heat engines, the development of X-ray lasers, and new methods of accelerating charged particles.

A recent accomplishment of this subprogram is the development of a liquid membrane for enriching the oxygen content in air, a concept proposed and developed by scientists at Bend Research, Inc., a small business in Bend, Oregon. Oxygen is preferentially transported across the membrane by a chemical agent that plays a role analogous to that of hemoglobin in blood. Oxygen enrichment is several times more efficient than with solid membranes, and oxygen-enriched air, which is important for efficient combustion and crucial for high-BTU coal gasification, could be produced at great savings in energy and cost.

Additional information about the current activities of this subprogram is available from Ryszard Gajewski, Director, Division of Advanced Energy Projects, Office of Basic Energy Sciences, ER-16, Department of Energy, Washington, DC 20545. An annual report, *Program Description and Summaries of Fiscal Year 1981 Activities* (DOE/ER-0107, October 1981), also provides more detailed information on this subprogram.

Biological Energy Research

The principal objective of Biological Energy Research is to provide basic information and conceptual understanding in microbiological and botanical sciences for DOE's efforts in biomass production of fuels and chemicals, microbiological transformation of organic materials for conservation, and biological systems for resource recovery. The research is aimed at enhancing biomass productivity, converting biomass and other organic materials into fuel and chemicals by novel and improved methods of fermentation, and developing biosystems capable of saving money.

The Biological Energy Research subprogram focuses on understanding the limits of biomass productivity in green plants, how plants adapt to suboptimal conditions of growth, such as those encountered in marginal lands and waters, and the mechanisms of microbial conversion of various biomass forms. In particular, the biochemical pathways of degradation of abundant materials such as cellulose, hemicelluloses, and lignins and the conversion of these materials to fuels or chemicals are studied.

Microorganisms that grow in the absence of oxygen and are able to carry out fermentation with high efficiency are of special interest, as are thermophilic microorganisms, which have optimal growth and conversion rates at high temperatures. An integral part of the subprogram is the development of genetic information that may ultimately be used to produce new or improved microorganisms and plants to facilitate the production of fuels or petroleum-conserving chemicals or to yield biotechnologies capable of conserving energy.

This research into the physiology, biochemistry, and genetics of microorganisms and plants is carried out primarily at university laboratories.

Further information on this subprogram can be obtained from Robert Rabson, Director, Division of Biological Energy Research, Office of Basic Energy Sciences, Department of Energy, Washington, DC 20545. Also available is the *Annual Report and Summaries of FY 1982 Activities* (DOE/ER-0147, October 1982), which provides detailed descriptions of ongoing activities.

Carbon Dioxide Research

The objective of the Carbon Dioxide Research subprogram is to improve scientific understanding of possible CO_2 sources and sinks, CO_2-induced climate modifications, and direct fertilization effects of CO_2 on vegetation. The global CO_2 content of the atmosphere has increased in recent history and continues to rise at a rate of about 1.5 parts per million per year. The effects of increased CO_2 in the atmosphere are uncertain. Scientists agree, however, that it can cause global climate changes involving temperature, precipitation, and wind circulation and that it may create a "fertilizer effect," which would increase crop yield and result in greater storage of fossil-fuel CO_2 by forests.

Carbon Dioxide Research aims to establish knowns and unknowns, reduce and specify uncertainties, increase data collection, and improve measurements and models directed at answering specific questions about the sources and sinks of CO_2, climate, and other possible effects.

Much of the current research is focused on defining and measuring fluxes of CO_2 among major sources and sinks of the carbon cycle. Research efforts also include estimates of global and regional changes in temperature and precipitation aimed at identifying which climate changes result directly

from the effects of CO_2 (as differentiated from the many other factors that could have been involved). General circulation models are being used to determine how atmospheric CO_2-induced climate change may relate to the nonatmospheric components of the climate system, such as oceans, land, and the cryosphere. Preliminary results of studies with nonatmospheric-ocean models suggest that effects may be delayed a decade or more by the thermal inertia of the oceans. The photosynthesis, physiology, and water use of plants and trees are also being studied to provide a basis for predicting the responses of vegetation to rising atmospheric CO_2.

In 1977, DOE and several other interested federal agencies began a concerted effort to define the CO_2 issue. These efforts are now being coordinated by the National Climate Program Office, established by the National Climate Program Act (P.L. 95-367) and administered by the National Oceanic and Atmospheric Administration. Interagency budget planning, program review, and coordination of research is handled through the Interagency Committee on Carbon Dioxide and Climate, which is chaired by DOE, as the lead agency for investigation of CO_2. Other agencies involved in the program include the National Aeronautics and Space Administration, the U. S. Geological Survey, the Department of State, the Environmental Protection Agency, and the National Bureau of Standards.

Additional information about this subprogram is available from Frederick A. Koomanoff, Director, Division of Carbon Dioxide Research, Office of Basic Energy Sciences, Department of Energy, Washington, DC 20545.

Major BES Facilities

Basic research in most areas pertinent to the DOE mission requires highly complex equipment and facilities. As mentioned earlier, the construction and operation of such facilities is costly, but many research projects rely on their availability. Basic Energy Sciences currently operates a number of vital facilities that are unique in the United States and, in some cases, in the world. The major BES facilities are described and their functions discussed briefly in the following subsections.

High Flux Beam Reactor

Brookhaven National Laboratory, Upton, New York

The High Flux Beam Reactor (HFBR) produces high-intensity neutron beams for research in a wide variety of fields. Neutrons are used as probes by nuclear and solid-state physicists, chemists, and biologists. Neutron scattering techniques continue to yield information on the fundamental properties and behavior of materials and chemical and biological substances which cannot be obtained by any other means. The HFBR is one of two high-flux research reactors supported by DOE, both of which are world-class research reactors for neutron research.

Current research using the HFBR includes studies of:

- The structure and dynamics of magnetic materials by elastic and inelastic neutron scattering
- The dynamics of materials as they change phase by quasi-elastic neutron scattering
- Neutron irradiation effects on the physical properties of materials
- The molecular structure and dynamics of organometallic substances
- Small-angle neutron scattering of biological substances
- The lattice structure and dynamics in condensed matter systems
- Amorphous materials—short-range order and excitations
- The neutron spectroscopy of low-lying excited states in solids

The HFBR, which cost $12.5 million to build, became available for research in 1965. Originally 40 MW, its power is being increased to 60 MW in 1982. The reactor has a maximum thermal neutron flux of 1.1×10^{15} neutrons/cm^2-sec available for research. Several of the nine experimental beam ports are used by more than one scattering instrument; three are used for nuclear physics research, and the rest for neutron diffraction or scattering research. The reactor can also be used to irradiate samples through any one of seven different vertical access tubes. The in-core total flux is 2.4×10^{15} neutrons/cm^2-sec. The building that houses the reactor and ancillary equipment has floor space for experimental apparatus. A new cold moderator facility, which will be the largest source of very low energy neutrons in the United States, is being developed.

High Flux Isotope Reactor

Oak Ridge National Laboratory, Oak Ridge, Tennessee

The High Flux Isotope Reactor (HFIR) has a high thermal neutron flux designed for production of transplutonium elements. This facility is critical to the Transplutonium Production Program of DOE. In addition to producing transplutonium elements, HFIR has four ports to permit the extraction of neutron beams from the reactor core for experimental purposes. The high flux and experimental capabilities make HFIR a unique research reactor, important not only for isotope production but also for neutron scattering, nuclear chemistry, and radiation damage research.

Although the use of HFIR has changed direction over the years, with increased emphasis on neutron irradiation and beam research and radioisotope production for sales, transplutonium isotope production continues to be the major effort. With the shutdown of the General Electric Test Reactor, which was a commercial supplier of a variety of radioisotopes, HFIR provides substantial quantities of radioisotopes to the industrial community. These sales, at full cost recovery, have resulted in revenues to HFIR of about $800,000 to $1,000,000 annually.

The HFIR cost about $15 million to build and attained its operating power of 100 MW in 1966, with a thermal flux in the target area of 2 to 5×10^{15} neutrons/cm^2-sec. It has a unique, one-piece core, which is its fuel element; this core is about the size of a 30-gal drum and is replaced after about 4 weeks of operation. In addition to isotope production activities and in-core irradiations, there are twelve research stations at four experimental ports.

In FY 1981 total HFIR operating costs were about $5.6 million, of which about $1.5 million was defrayed by non-BES user research programs and radioisotope sales. The BES-supported research activities at HFIR in FY 1981 were about $5 million. Other research at HFIR is supported by the Fusion and Fission Energy Programs, the Nuclear Regulatory Commission, and the National Science Foundation.

National Synchrotron Light Source

Brookhaven National Laboratory, Upton, New York

The National Synchrotron Light Source (NSLS) is a unique user-oriented facility for advanced multidisciplinary research with synchrotron radiation. At NSLS a wide range of research techniques are used by biologists, chemists, solid-state physicists, metallurgists, and engineers for basic and applied studies. Among the techniques are extended X-ray absorption fine structure (EXAFS), scattering, diffraction, topography, fluorescence, interferometry, gas phase spectroscopy, photoemission, lithography, microscopy, dichroism, and infrared vibrational spectroscopy.

The highly intense radiation emitted by electrons travelling in circular paths at very high energies is referred to as synchrotron light. Synchrotron light radiation from the NSLS is continuous in spectrum, stable, pulsed, and high in intensity, with the spectral peak related to the electron energy and radius of the circular orbit. Some applications of the interaction of synchrotron radiation with matter are:

- Studies of the state and behavior of gases
- Studies of the surface of solids
- Studies of metal atoms in biological systems
- Analysis of the atomic structure of microscopic samples
- Microscopy
- Research related to the miniaturization of computer chips

The NSLS, which began operating in 1981, includes two electron storage rings—an X-ray ring about 170 m in circumference, which provides 28 photon ports, each able to handle one or more experiments, and a vacuum ultraviolet (VUV) ring 44 m in circumference, with 16 photon ports. A common injector meets the high-current requirement (1.0 A) for both rings. Circulating beams have been achieved in both rings, but most of the effort in 1982 has been on the VUV ring. Acceleration to 600 MeV (700 MeV design) and injection are now routinely achieved in the VUV ring, and currents up to 0.25 A, peak, and 100 mA, steady state (lifetime, 1 hr), are now possible and will be exceeded in the future. In 1982 the users included individual university researchers, national laboratory teams, and industrial researchers from such Fortune 500 corporations as IBM, Exxon, Bell Laboratories, DuPont, General Electric, and Mobil. The authorized construction cost for NSLS ($24 million) provided for the building, storage rings, and a limited amount of experimental equipment for four of the beam ports. Substantial additional instrumentation and equipment will be needed as the research effort builds up. Private industry has already committed approximately $7 million for equipment to conduct research at NSLS.

Intense Pulsed Neutron Source

Argonne National Laboratory, Argonne, Illinois

The Intense Pulsed Neutron Source (IPNS) is a dedicated user-oriented facility for advanced multidisciplinary research with pulsed neutrons, serving the physics, materials, chemical, and life sciences research communities.

High-energy protons from a proton synchrotron impinging on a heavy metal target produce bursts of spallation neutrons. The resulting pulsed beams of neutrons, exploited using time of flight techniques, have the following characteristics:

- High peak intensity thermal neutrons
- High peak intensity epithermal neutrons
- Pulsed delivery for investigating time-dependent phenomena, such as following shock waves, heat pulses, or laser flashes

In materials research, pulsed neutrons can be used to study:

- Static and dynamic properties of liquids and amorphous solids
- Defects, voids, and aggregates in materials
- Structure and dynamics of polymers and biological material
- Magnetic, crystallographic, and electronic changes
- Phonon structure and magnetic excitations in solids
- Surface phenomena and superconductivity
- Radiation damage studies at cryogenic temperatures

The IPNS began operation in FY 1981 and is expected to meet full operating characteristics by mid FY 1983. It has the following operating characteristics:

Proton current	8 μA
Protons/pulse	2×10^{12}
Proton energy	500 MeV
Repetition rate	30 Hz
Peak thermal flux	3×10^{14} neutrons/cm^2-sec
Peak epithermal flux (1 eV)	10^{15} neutrons/cm^2-sec
Time-average fast flux (>0.1 MeV)	2×10^{12} neutrons/cm^2-sec

The neutron scattering assembly has seven spectrometer stations, and the radiation effects assembly includes two cryostat stations for investigations at 4°K. Six additional facilities are available for special experiments with, for example, solid He^3, polarized neutrons, and ultracold neutrons, and for high-temperature irradiations. During the initial experimental period in 1982, 29 of the 38 experiments performed were by outside users.

The authorized construction cost for IPNS ($6.4 million) provided for beam transfer from the proton synchrotron and construction of the spallation target area. In addition, $2.4 million was provided to upgrade the experimental capability with a variety of spectrometers, detectors, and computer interfaces.

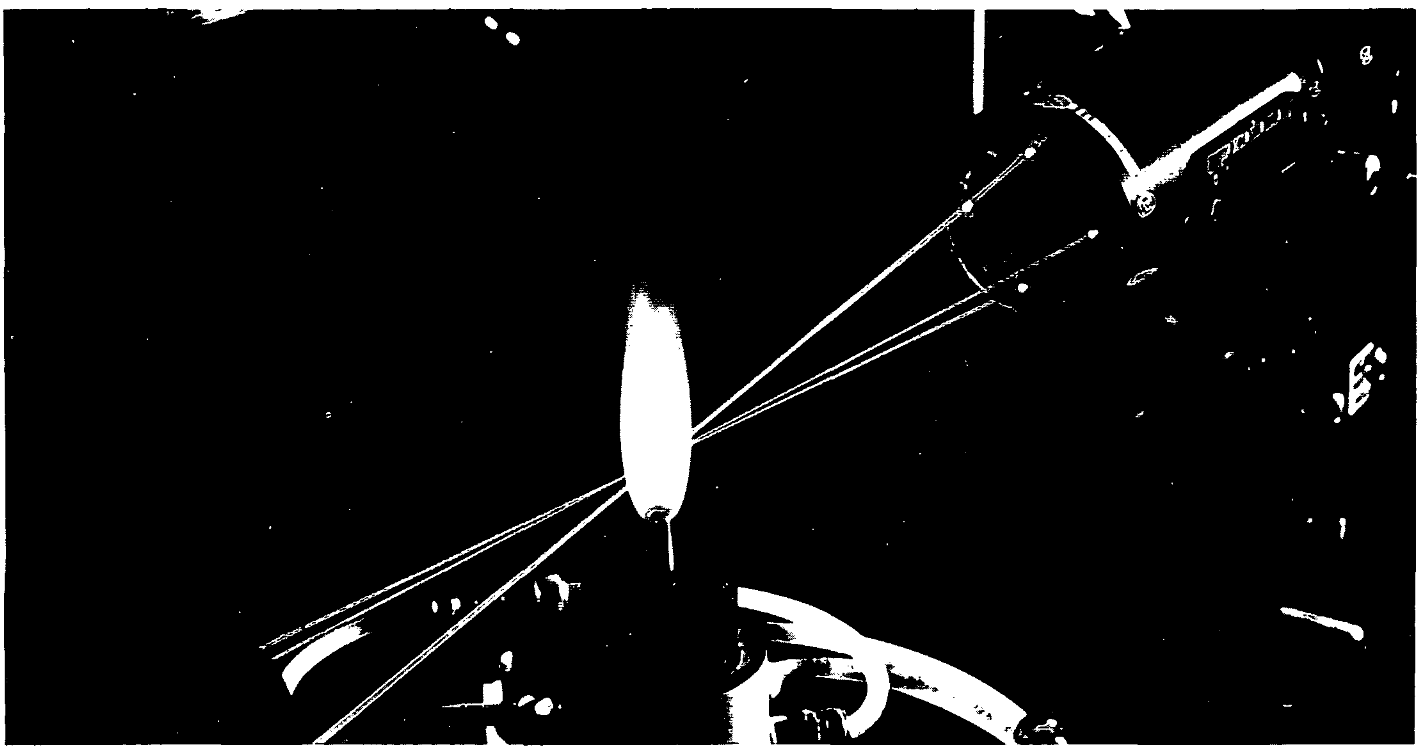
Combustion Research Facility

Sandia National Laboratory, Livermore, California

The Combustion Research Facility (CRF), which cost $10.3 million, provides a range of instrumentation not available in other laboratories and, thus, provides a unique capability to outside users for combustion research. It is expected to receive considerable use by non-DOE groups. The focus of the laboratory is on laser diagnostics of combustion systems, but a variety of burner systems and special facilities are available, including those for research on coal combustion and internal combustion engines. The staff at CRF provides users with technical support covering such diverse fields as chemistry, fluid dynamics, computer modeling, and pure and applied spectroscopy. The CRF research staff also has the necessary scientific strengths to serve the DOE combustion program's research objectives—maximizing the efficiency of processes while minimizing the production of undesirable pollutants. Examples of research that will be carried on at CRF include:

- Detection and measurement in flames of short-lived reactive intermediates in key combustion reactions
- Modeling and improvement of the use of ammonia to reduce NO_x emission from combustion processes
- Laser velocimetry to study turbulence effects in an internal combustion engine
- In situ laser diagnostics of the interactions of materials surfaces with flames

The CRF, a building with fourteen individual research laboratories, four special laser laboratories, and a variety of support laboratories, was dedicated in early March 1981. On demand, laser output can be beamed to any one of the individual research laboratories for use in a large variety of experiments. Also included are computer facilities linked to a large mainframe computer located elsewhere in the Sandia complex.



High-Voltage and Atomic Resolution Electron Microscopes

High-Voltage Electron Microscopes (HVEM) are invaluable for energy-related research important to, e.g., fission and fusion (radiation damage), automotive (high-strength steel and high-temperature ceramics for automotive turbines), fossil (corrosion), and solar (photovoltaics) technologies. The microscopes are also important for general research, and each institution having one has developed or is developing a sizeable outside user group of academic and industrial scientists.

The HVEM is useful for transmission electron microscopy of heavy metals, studies that must use "thick" samples to avoid surface effects, and studies of brittle materials, such as ceramics, which are difficult to prepare in thin form. Also, high-voltage machines are necessary for materials studies incorporating special environments and for in situ radiation damage studies. It is possible to "see" damage as it is being produced. The only other federal agency supporting MeV microscopes is the National Institutes of Health, which has four machines for medical and biological research.

Basic Energy Sciences supports three HVEM's and the atomic resolution microscope (ARM), which is projected to come on-line in 1983. The ARM, which will be delivered to Lawrence Berkeley Laboratory in 1982, will have an imaging resolution capability superior to any currently available machine in the United States. The four microscopes are:

- The 1.0-MeV HVEM at Oak Ridge National Laboratory (ORNL), which came on-line in 1977. About 40% of the use in 1981 was allocated to eleven projects for external (non-ORNL) users at both university and industrial laboratories. The major research involves corrosion and deformation studies in situ in the microscope and observation of specimens where the high penetration capability of the electron beam is essential.
- The 1.2 MeV HVEM at Argonne National Laboratory (ANL), which came on-line in 1979. This microscope is interfaced with a 2-MeV tandem accelerator and a 0.3-MeV ion accelerator. The facility provides a unique capability for advanced microscopy, ion implantation, and ion beam analysis. In 1981, 25 projects, slightly more than half of which were from external (non-ANL) users—predominantly universities, were in progress. The tandem accelerator was installed and calibrated, and the ion accelerator interface to the microscope was completed in 1982.
- The 1.5-MeV HVEM at Lawrence Berkeley Laboratory, which came on-line in 1982. The highest voltage microscope in the United States, it is equipped with special accessories that permit the direct study of the effects of high temperatures, corrosive environments, and mechanical forces on microstructure and microstructural behavior.
- The ARM at Lawrence Berkeley Laboratory, which will be on-line in 1983. Its cost will total $3.0 million, plus $3.0 million for housing and backup facilities. It will have a maximum voltage of 1 MeV and a point-to-point resolution of 1.7 Å.

Oak Ridge Electron Linear Accelerator

Oak Ridge National Laboratory, Oak Ridge, Tennessee

The Oak Ridge Electron Linear Accelerator (ORELA), a facility of continuing importance in the development of fission and fusion energy technologies, is used for measurements of neutron cross sections over a whole range of thermal energies, from 0.02 eV to 80 MeV. These cross sections are needed to design and operate nuclear fusion and fission power reactors and to study some aspects of nuclear reaction mechanisms and nuclear structure. At present cross sections are best measured by repetitive, intense neutron pulses and the short-burst performance of ORELA. Energy-dependent neutron cross section and related measurements of almost every variety are made with this facility. The ORELA has recently been upgraded with a new electron gun and klystron pre-bunching system to increase the effective neutron output.

The ORELA, which was built in 1969 at a cost of $10 million, provides 22 A peak currents of 100- to 170-MeV electrons at burst widths from 3 to 24 nsec at the rate of 25 to 1200 pulses/sec. The electrons impinge on a target material producing the desired neutrons. At an average power of 50 kW, 10^{14} neutrons/sec, time averaged, or 4×10^{18} neutrons/sec, peak, are produced. The design of ORELA, which includes eleven flight paths radiating from an evacuated target room, makes possible simultaneous use by many experimenters, a feature that greatly increases the total output and cost-effectiveness of the facility.

Transuranium Processing Plant

Oak Ridge National Laboratory, Oak Ridge, Tennessee

The Transuranium Processing Plant (TRU) was built to recover radioactive transuranium elements from irradiated targets and to serve other chemical processing and fabrication needs of the Transplutonium Production Program of the Atomic Energy Commission. It is not a research facility for BES, but it provides unique chemical processing capabilities for highly radioactive actinide materials. Research in nuclear chemistry and physics and nuclear technology, especially as related to fission energy development and to fundamental behavior of the actinide radionuclides that pose significant problems in nuclear waste treatment and isolation, is supported by TRU activities. A nuclear energy program "user" group currently in residence at TRU operates the Solvent Extraction Test Facility, which is part of the ORNL Consolidated Fuel Reprocessing Program.

Samples ranging from hundreds of grams of curium-244 to picograms (10^{-12}) of fermium-257 have been provided by TRU, and research quantities of a variety of transuranium isotopes prepared at TRU have contributed to our understanding of the chemical, physical, and nuclear properties of the actinide elements.

The TRU, built at a cost of $8.8 million, began "hot" operation in 1966. It contains seven hot cells, each equipped to carry out remotely one or more separate procedures for chemical separation, purification, fabrication, or analysis of highly radioactive materials.

In addition to its use for the nuclear energy program's solvent extraction research and development, the facility also contributes to DOE's isotope production and sales activities.

5-MeV Dynamitron Accelerator

Argonne National Laboratory, Argonne, Illinois

The Argonne Dynamitron accelerator provides intense, highly collimated direct-current beams of fast atomic or molecular ionic projectiles for use in experiments in atomic physics, nuclear research, and the irradiation of materials. In operation since 1968, it has been steadily improved over the years. It is a powerful, versatile, and reliable facility that also includes computer systems for control and data acquisition.

Present applications of the accelerator include studies of the interactions of fast molecular ions with matter, determination of molecular ion structures, beam-foil spectroscopy, and ion channeling in crystals. Nuclear research includes weak interaction studies, measurements of parity violation in nuclei, quark searches, and measurements of the cross section for reactions between light nuclei. The materials research is centered on damage studies related to the first-wall problem in fusion reactors.

A valuable feature of the machine is that a broad range of positive-ion projectile species can be accelerated and analyzed magnetically. There are six fully instrumented beam lines, including one with a unique capability for experiments requiring extremely high angular resolution and one equipped for simultaneous dual-beam irradiations with a magnetically analyzed beam from a neighboring 20-MeV Van de Graaff accelerator merged with the Dynamitron beam. The accelerator voltage can be varied smoothly between 0.3 and 5.0 MeV. Monatomic positive-ion beams of most of the elements are readily produced, as are molecular-ion beams, including such complex projectiles as $C_6H_6^+$. Most beams are available at the microampere level, and some (e.g., hydrogen and deuterium beams) at the milliampere level, continuously or in a pulsed mode down to a few tenths of a nanosecond and at repetition rates variable up to 8 MHz.

Calutrons—Electromagnetic Isotope Separations Facility

Oak Ridge National Laboratory, Oak Ridge, Tennessee

The electromagnetic isotope separations facility at Oak Ridge National Laboratory (ORNL) enriches stable isotopes, selected radioactive isotopes, and heavy-element isotopes for use in research and development and in commercial activities. It consists of very high current mass separators, known as Calutrons, which were originally designed and built under the Manhattan Project during World War II. The Calutron facility is a unique national asset; the USSR is the only other nation possessing such a facility. Many other countries have laboratories in which isotopes are enriched, but these facilities are usually of limited size and the isotopes are used for specific purposes. Research and development directed toward increasing both the throughput and the isotopic purity of the products is also conducted at ORNL. The Isotope Sales Office distributes the isotopes in two ways: Multigram quantities of enriched samples from the Research Materials Collection are loaned to members of the DOE research community at a nominal fee for nondestructive research, and enriched isotopes are sold to other research and commercial organizations on a cost-recovery basis.

The facility consists of two "tracks" of thirty Calutrons each. One track is reserved for stable isotope enrichment, and the other separates chemically hazardous, radioactive, and actinide elements. The horizontal magnetic field of the stable isotope track is subdivided into four segments by magnetic shunts that extend from one side of the track to the other. The resulting three banks of eight separators and one bank of six separators can be used independently. If the magnetic field in each separate segment is excited, it is theoretically possible to enrich the isotopes of four elements simultaneously in the thirty Calutrons.

When feed material, in either elemental or compound form, is introduced into a Calutron, it is either directly vaporized or heated with chemical treatment to form a volatile species. This vapor is then introduced into an arc discharge, where it is ionized in the high-current source. The ionized particle is extracted from the ion source, accelerated, and magnetically focused. The focused individual isotopic beams are intercepted by collectors constructed of carbon, copper, or aluminum. After a run, the duration of which may be fifty to several hundred hours depending on the element, the collectors are removed from the separator, and the material is extracted, chemically purified, assayed, and placed in the inventory.

Since each element or compound has unique operating characteristics, it is difficult to generalize about the throughput capability of the facility. Typical beam currents are between 10 and 100 mA, with an average of 25 to 50 mA. As a rule of thumb, one separator can provide approximately 0.1 mole of an element per day of operation. This figure is multiplied by the natural isotopic abundance to determine the yield for a particular isotope. Isotopic purity depends on the natural isotopic abundance of the isotope required and the abundance of its nearest neighbors. The products of one separation can be recycled to obtain a significantly higher isotopic assay in a two-pass process.

Materials are available from the Research Materials Collection (RMC) for loan to U. S. scientists for use in nondestructive experiments and to non-U. S. scientists under restrictive conditions (e.g., the experiment must be of direct relevance to the DOE technology programs, such as the use of RMC samples within the European community for the study of neutron cross sections). Such loans are usually made only on the strong recommendation of the U. S. Nuclear Data Committee.

Materials are sold from the sales inventory to anyone on a first-come, first-served basis. Up-to-date information on the electromagnetically enriched isotopes, their chemical form, percent enrichment, price per milligram, and availability can be obtained from E. Newman, Operations Division, ORNL, P. O. Box X, Oak Ridge, TN 37830.

Program and Budget Trends

As the office responsible for the long-term mission-oriented research in the Department of Energy, Basic Energy Sciences is committed to continuing studies in the physical sciences. It has funded and conducted creative research programs and managed complex facilities for DOE and its predecessor organizations since the 1940's, a period of unparalleled scientific growth and development.

The shorter term programs of BES contribute vital information to developing technologies, and its long-range research, although by its very nature not likely to advance DOE's short-term goals, will be the source of new ideas and concepts for the development of totally new technologies. It is a necessary investment in the future. Such uninterrupted research programs are invaluable to the nation in providing a knowledge base on which to build. Because of its experience, diversity, and unique capabilities, BES is able to respond to growth and new directions in national goals and missions.

The research responsibilities of BES have expanded over the past ten years to include knowledge required by nonnuclear energy technologies. At the same time, however, BES's budget growth has, in real terms, been small—on the order of 2 or 3% per year. The budget for FY 1982 was approximately $255 million, earmarked for three distinct categories of expenses—operating costs, equipment, and construction (Table 1). The largest percentage (over 90%) was operating expenses; approximately 6% went to capital equipment, and less than 1% was spent for construction. Some changes in responsibility occurred at the end of FY 1982; for example, research support in Low Energy Physics, at an annual level of $12 million, was transferred from the BES Nuclear Sciences subprogram to DOE's High Energy and Nuclear Physics program, and BES assumed responsibility for support of the Stanford Synchrotron Radiation Laboratory from the National Science Foundation. Earlier, at the beginning of FY 1982, the Carbon Dioxide Research subprogram was assigned to BES.

Figure 2 presents a breakdown of the performers who carry out the Basic Energy Sciences program. About 56% of the program is conducted at the national laboratories, 26% at universities, and the remainder elsewhere, including nonprofit institutions and industry. Plans are to maintain the university portion of the program at about 26%, excluding Ames Laboratory and Lawrence Berkeley Laboratory (LBL). These two major laboratories, which are colocated with universities (Lawrence Berkeley at the University of California, Berkeley, and Ames at Iowa State University), receive one-sixth of the BES support going to national laboratories. If they are included with the universities, that portion of the program rises to 38%, with a corresponding decrease under national laboratories. The research supported by BES at Ames and LBL is conducted almost entirely by faculty members and graduate and postdoctoral students.

Of the funding going to national laboratories, about 90% is for activities uniquely dependent on the facilities and services at the specific laboratories supported. The operation of major scientific facilities requires a large commitment of BES funds. Operating costs for facilities in FY 1982, exclusive of the costs of research done at the facilities, were $29 million. In FY 1983, with the assumption of responsibility for support of the Stanford Synchrotron Radiation Laboratory, these costs are expected to exceed $42 million.

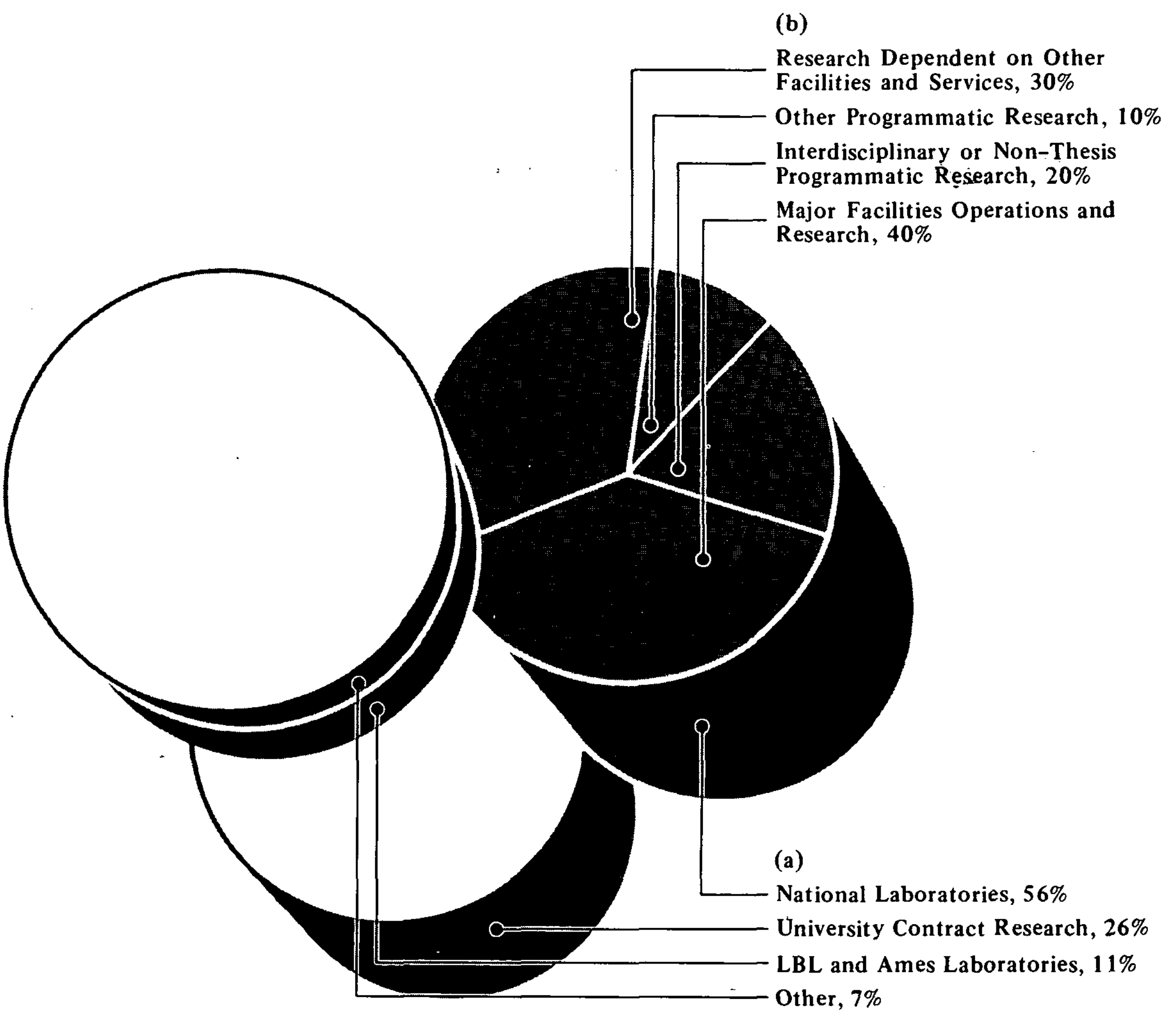
The future for BES appears more and more challenging as the frontiers of science are expanded. Current trends are toward greater use of the major facilities, by both DOE and "outside" researchers, and strengthening of research in the areas of nuclear waste isolation, surface modification, interfaces, grain boundaries, condensed matter theory, amorphous materials, structural ceramics, nondestructive evaluation, etc.

Table 1 Office of Basic Energy Sciences Budget

	FY 1981, 10^6 dollars	**FY 1982, 10^6 dollars**
Operating expenses (by subprogram)		
Materials Sciences	89.1	95.5
Chemical Sciences	59.7	63.2
Nuclear Sciences	20.5	22.4
Engineering, Mathematical, and Geosciences	24.1	24.9
Advanced Energy Projects	6.3	7.3
Biological Energy Research	7.3	8.4
Carbon Dioxide Research	9.7	12.0
Program Direction	2.5	2.5
Subtotal	**219.2**	**236.2**
Capital Equipment	**14.5**	**16.4**
Construction	**3.5**	**0.6**
Total	**237.2**	**253.2**

Experiments with, for example, phenomena involving extremely short time periods, vanishingly small concentrations of reacting species, entities with only transient existence, and measurements under extreme conditions of temperature and pressure point out the necessity for constantly improving equipment. An example of BES's concern in this area, the support of the atomic resolution microscope, which will come on-line in 1983, was mentioned earlier. The ARM will have superior resolution to any microscope currently available in the United States. Despite increasing costs and heavier use of equipment and installations, the unique research programs and facilities supported by BES must be maintained, improved, and expanded. The knowledge base they create is vital to improving and developing energy technologies.

Figure 2 Breakdown of research by (a) performers and (b) nature of research activities at national laboratories.



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