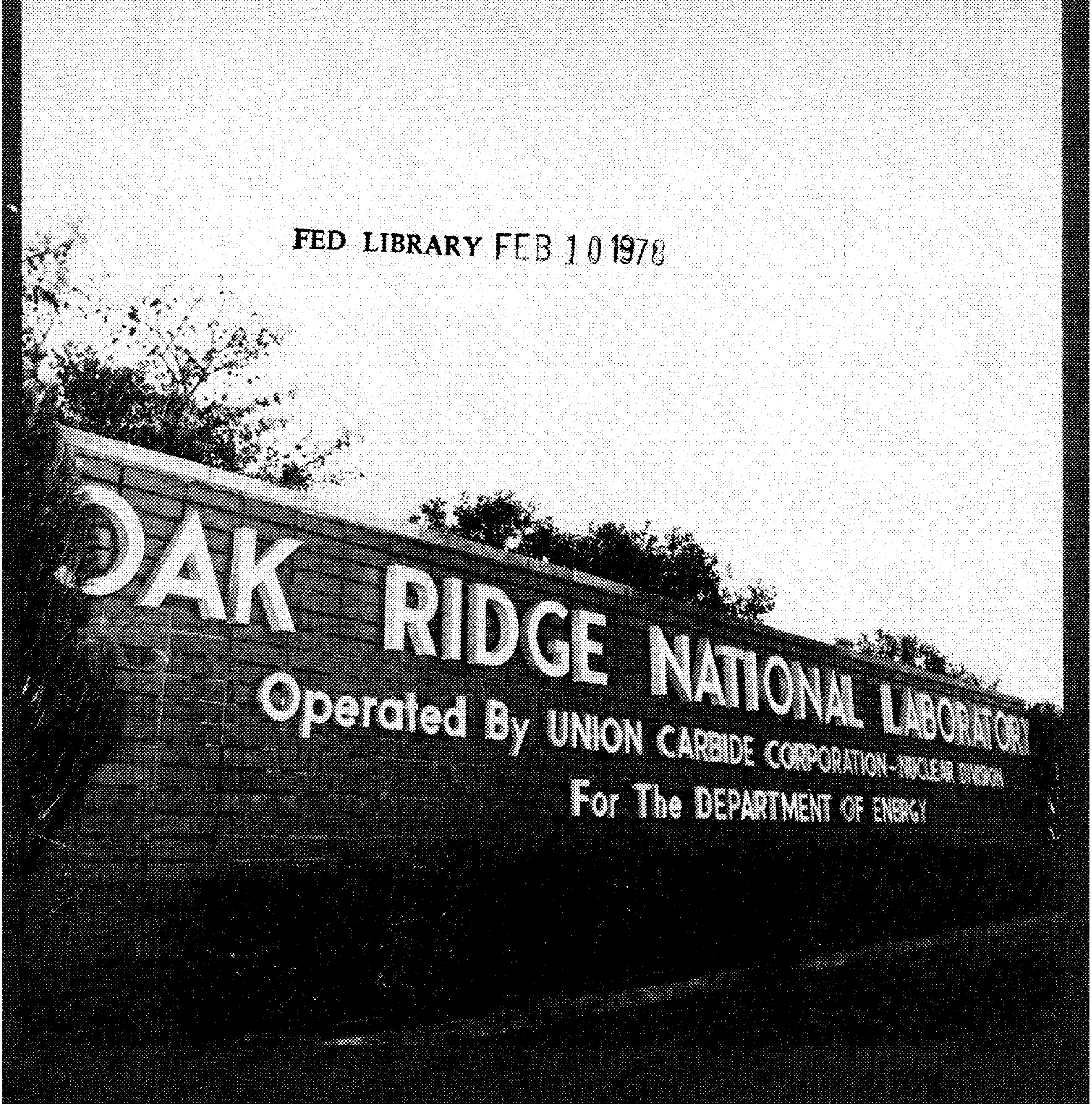
ORNL/PPA-78/1

Institutional Plan 1977 · 1983

December 1977



The information in this Plan was obtained with the cooperation of the professional staff of the Oak Ridge National Laboratory. Additional copies of the *Institutional Plan 1977-1983* may be obtained from the Program Planning and Analysis Office, Building 4500N, Oak Ridge National Laboratory, P.O. Box X, Oak Ridge, Tennessee 37830. Telephone: 483-8611, extension 3-1411 (FTS 850-1411).

ORNL/PPA-78/1

INSTITUTIONAL PLAN 1977–1983
OAK RIDGE NATIONAL LABORATORY

DATE PUBLISHED—DECEMBER 1977

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OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37830
operated by
UNION CARBIDE CORPORATION
for the
DEPARTMENT OF ENERGY

CONTENTS

All post-1979 expenditure figures are given in constant 1979 dollars. Details in tables may not add to totals because of rounding. All dates in tables are for fiscal years.

Executive Summary

1. EXECUTIVE SUMMARY

Laboratory Director's Perspective

This is the fourth in a series of long-range plans which began as internal documents and have now evolved into the Institutional Plans requested by the Department of Energy (DOE).

Some retrospective overview is important, for between the late 1960s and the early 1970s the AEC/ERDA-funded* staffing level at Oak Ridge National Laboratory (ORNL) decreased rapidly, by approximately 30% (Fig. 1). Not until the end of the current year will the Laboratory regain its former level of staffing.

We have emerged from this period with Laboratory programs that are a more balanced match to the research, development, and demonstration activities of DOE. At present there are four major activities at the Laboratory of approximately equal proportions: nuclear energy development, basic physical research, fusion energy, and environmental and biomedical sciences. However, we anticipate that by the end of the period covered in this *Institutional Plan*, activities related to fossil energy will have grown to match the others in size and that programs in conservation will also have increased substantially. These points are summarized in Fig. 2 and Table 1. Appendix A gives detailed tables of resource projections.

In the past few years there has been a noticeable shift in the kinds of basic research being done, as well as a shift from the basic and applied sciences toward development and demonstration activities. We expect these trends to continue, but at a slower pace, during the remainder of the decade.

A number of severe problems relating to capital budgets have arisen. The new programs, as well as important changes in the traditional areas of activity, have created unique requirements which are not met by our present buildings, most of which have been in use for 35 years and are deteriorating. The ability to correct this deterioration and to make modifications in the buildings to match changes in programs is normally taken care of through the use of general plant project (GPP) funds, but in the case of ORNL those funds have actually been decreasing by approximately 20–30% per year, while the Laboratory staff has been growing. In this respect, we regard the Energy Systems Research Laboratory and, later, the Information Resource Center for Energy and the Environment as essential if we are to meet present commitments in an efficient and timely way while retaining the flexibility to reorient programs in response to changing missions.

*Funded by the U.S. Atomic Energy Commission (AEC), 1947–1974, and the Energy Research and Development Administration (ERDA), 1975–1977. Both agencies' research programs are now administered by DOE.

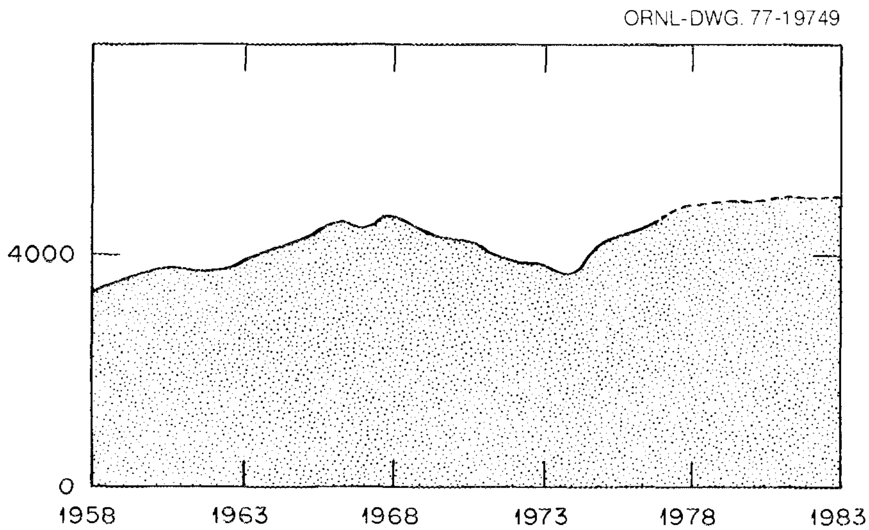


Fig. 1. History of personnel numbers at ORNL (full-time equivalents). Between 1968 and 1974 personnel numbers fell rapidly. The last few years have seen increases, but staffing levels are still below their 1968 high.

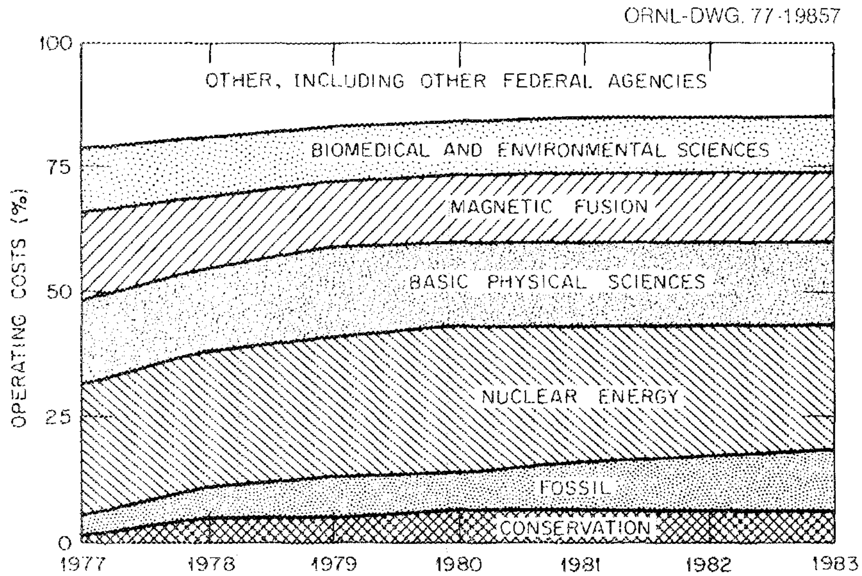


Fig. 2. Projected changes in ORNL programs. The most significant change during this period is expected to be the growth of activities in the areas of fossil fuel and conservation.

Table 1. Summary of Laboratory forecasts

	1977	1978	1979	1980	1981	1982	1983
Operating costs (millions of dollars, budget outlays)							
Fossil	8	14	20	25	30	35	40
Conservation	4	11	14	17	18	19	19
Solar, geothermal, and fusion	35	35	39	42	45	48	49
Basic physical sciences	34	37	47	47[a]	47	47	47
Biomedical and environmental sciences	26	28	30	32	34	35	37
Nuclear energy	50	62	76	83	85	82	79
Overall projection (DOE only)[b]	157	187	205	220	230	240	250
Other federal agencies	38	40	42	43	43	43	44
Total[b]	195	227	247	263	273	283	294
Extramural expenditure	24	40	50	63	67	69	70
Intramural expenditure[b]	171	187	197	200	206	214	224
Personnel (full-time equivalents[c])							
Fossil	190	220	270	340	400	460	520
Conservation	94	100	150	170	180	200	210
Solar, geothermal, and fusion	433	435	450	460	480	480	490
Basic physical sciences	934	980	1150	1150[a]	1150	1150	1150
Biomedical and environmental sciences	825	890	910	980	1030	1080	1130
Nuclear energy	1102	1215	1430	1570	1520	1460	1410
Other federal agencies	1020	1050	1120	1130	1140	1140	1150
Overall projection[b]	4600	4850	4900	4900	5000	5000	5000

[a]In the absence of detailed guidance from Headquarters we project a constant level of effort beyond FY 1979.

[b]These figures represent the Laboratory's best estimates of total operating budgets or personnel for those years. They do not equal the sum of all the individual programs or subprograms.

[c]This includes all ORNL staff, full- and part-time, permanent and temporary. In addition, there will be approximately 1170 guest workers and students spending some time at ORNL during 1977. Approximately 200 man-years of engineering effort from UCC-ND Engineering at ORNL and 100 man-years of support services from the Y-12 Plant, as well as 130 man-years of programming effort and 50 other Computer Sciences Division staff, were used at ORNL during FY 1977.

The need for funds to apply sound energy conservation practices at the Laboratory must also be met. Almost no direct funds have been provided for this, and what we have done has been achieved through administrative practices and investments from operating or other funds, where practical. However, all of the large investments required for effective conservation in the long term must come as direct capital provided for that purpose.

While the emphasis of this document has been on programs and needs, the nature of our research contribution to the missions of DOE is also changing. This *Institutional Plan* indicates that more program management and technical support will be provided by the Laboratory; that is, the money will continue to grow but the increases will be used primarily for extramural research rather than for work done entirely in house (Fig. 3). We also anticipate a stronger regional role with universities, states, the Tennessee Valley Authority (TVA), and others within the Southeast.

ORNL is the principal contractor for the High-Temperature Gas-Cooled Reactor (HTGR) Fuel Recycle Program and the Advanced Fuel Recycle Program. The Laboratory also has a lead role in the work on structural materials for the liquid-metal fast breeder reactor (LMFBR). In fusion energy, we have a lead role for designing and testing the magnet systems of tokamaks to be built in the 1980s, and in fossil energy we have developed lead roles in planning and implementing a life sciences program in support of synthetic fuel development and in designing, building, and testing a Fluidized Bed Technology Test Unit. The Laboratory also has lead roles in low-temperature thermal energy storage and in regional energy development and utilization studies.

I believe that the overall planning goals presented in this document can be achieved and will contribute strongly to the DOE efforts. It is imperative, however, that the essential element of feedback from programmatic and institutional planners within DOE take place. All past long-range plans have lacked the perspective which this feedback would have given, and it is essential that such dialogue take place quickly and consistently if these Institutional Plans are to have any meaning.

Laboratory Goals and Management Philosophy

Oak Ridge National Laboratory is a national energy laboratory concerned with the development and efficient use of environmentally acceptable supplies of energy from various sources. It is a federal government facility owned by DOE, which sponsors most of the work carried out at the Laboratory. The major objectives of the Laboratory are:

- To develop new and environmentally acceptable energy technologies that will offer the

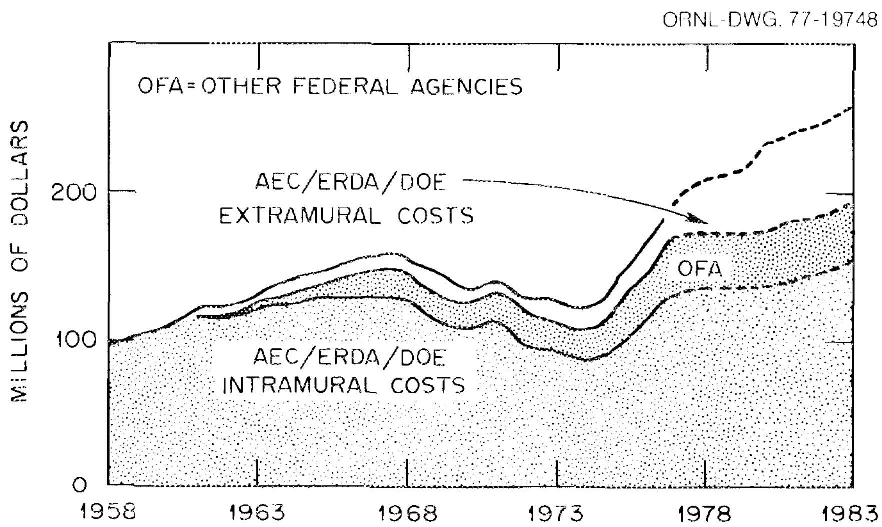


Fig. 3. History of operating costs at ORNL (constant 1977 dollars). The decline in funding levels which began in 1967 was reversed shortly after the oil embargo in 1973. Work for other agencies has increased markedly over the past 15 years. Subcontracting and procurement expenditure will increase in the next few years, so increases in personnel numbers will be much lower than increases in funding levels.

nation safe options for energy supply and efficient systems for energy use.

- To generate, analyze, and systematize new scientific knowledge.
- To perform research and development in support of other national needs where the Laboratory's experience or abilities permit us to make important contributions.

To determine what activities we will undertake, and to ensure that high-quality work is produced, the Laboratory will:

- Be responsive to the full range of DOE programs.
- Seek problems in technology development that are important to national energy needs; that use the Laboratory's multidisciplinary capabilities; and that have too high a risk for private industry.
- Seek to become a "lead laboratory" in important areas of technology development.
- Continue strong basic research programs in the physical and life sciences that are related to energy problems or use unique Laboratory facilities.
- Cooperate with industry and work for rapid transfer of new technologies to industry.
- Balance Laboratory activities to achieve an appropriate mixture of near-, middle-, and long-term programs.
- Maintain high-quality support organizations and facilities in engineering, computer science, instrumentation and controls, analytical chemistry, fabrication, maintenance, and industrial health and safety.
- Maintain a staff of exceptional quality through highly selective recruiting and careful personnel development.

Laboratory Programs and Planning Goals

The Laboratory program is currently dominated by four major areas of activity: nuclear energy development, basic physical research, fusion energy development, and biomedical and environmental sciences. Two other important programs, fossil energy and conservation, were relatively small in FY 1977, but we expect them to expand during the planning period covered here. The scope and direction of these programs over the next six years are briefly summarized here.

NUCLEAR ENERGY DEVELOPMENT

The Laboratory's program includes technology development and reactor safety research as well as all phases of the nuclear fuel cycle. The technology development program for breeder reactors concentrates on the development and testing of materials for special service conditions, high-temperature structural design methods, reactor instrumentation, nuclear cross-section measurement and evaluation, and experimental and analytical studies of shielding configurations and system safety and performance. Related developments for HTGRs and for special projects and space applications include high-temperature materials, fuels, fission product chemistry, and containment technology. Fuel cycle work involves management responsibility for the HTGR Fuel Recycle Program, development of techniques and equipment for reprocessing light-water-reactor (LWR) and advanced-reactor fuels, development of refabrication technology for HTGR and LWR fuels, and techniques for separation, stabilization, and eventual isolation and disposal of nuclear wastes.

A reactor safety program, conducted primarily for the Nuclear Regulatory Commission (NRC), concentrates on pressure vessel integrity, heat transfer under transient and accident conditions, and the behavior of structural materials and fission products under transient and accident conditions. Current work on commercial LWRs is designed to increase reactor reliability and define safe operating limits. Assistance to the NRC also involves work on environmental impact statements and related environmental and social impact research, preparation of "As Low As Reasonably Achievable" guides and assessment methodologies for the release of radioactive materials, work on siting of nuclear energy centers, and refinement of safeguards.

BASIC PHYSICAL RESEARCH

There are three components to the basic energy sciences program at ORNL: materials science, chemical science, and nuclear science. The materials science program includes fundamental studies of materials phenomena which underlie materials problems in nuclear and nonnuclear energy technologies. These phenomena include surface properties, superconductivity, radiation effects, diffusion, lattice dynamics, and magnetic structure. A major expansion in the materials program is expected in the area of high-temperature materials with the proposed High-Temperature Materials Laboratory (HTML).

The chemical research program has a large component which is concerned with the chemistry of the actinides and fission products and is relevant to the technology needs of the nuclear fuel processing and waste disposal programs. The size of these programs will remain constant in this planning period. An area of rapid expansion over the next five years will be the chemistry of processes common to fossil energy technologies, including catalysis in coal conversion processes. Programs in fused-salt chemistry relevant to high-temperature fuel cell and battery technology and thermal energy storage will also experience some growth.

The nuclear sciences program supports facilities [High-Flux Isotope Reactor (HFIR) and Transuranium Processing Plant (TRU)] for transuranium element production as well as the program for separation of stable isotopes. These are important resources for national as well as ORNL research needs. The Oak Ridge Electron Linear Accelerator (ORELA) will continue to provide data on neutron cross sections of critical importance to fission and fusion technology. The atomic physics program will expand in this planning period. It will focus on studies of energy-absorbing atomic processes of significance to plasma dynamics.

The nuclear physics program is dominated by topics related to heavy-ion physics. The present experimental program involves use of the Oak Ridge Isochronous Cyclotron (ORIC). The Holifield Heavy Ion Research Facility (HHIRF), which includes a 25-MV tandem electrostatic accelerator, will be operational in FY 1979. The facility will be the central element of DOE's heavy-ion physics program. A Phase II addition to HHIRF has been proposed for the FY 1979 budget. Phase II features a high-energy separated-sector cyclotron to be coupled to the HHIRF 25-MV tandem accelerator and to ORIC, which will result in significantly higher ion energies. Much of the research in nuclear physics is directed at the general advancement of science rather than a specific energy mission.

FUSION ENERGY DEVELOPMENT

The ORNL program in magnetic fusion energy is a broad program of research and development aimed at the development of an economically viable fusion reactor. The program covers all aspects of magnetic fusion development, including studies of toroidally confined plasmas, plasma heating by neutral-beam injection, development and fabrication of superconducting magnets, and fusion reactor technology. In the immediate future, plasma studies will use the Elmo Bumpy Torus (EBT) and Impurity Study Experiment (ISX). The technology program will utilize the Laboratory's ORR and HFIR reactors for materials irradiation, as well as a number of large test facilities for neutral beam and superconducting magnet development. Later the program will center about the Long-Pulse Technology Tokamak (LPTT) and the EBT-II, devices to be operational in the early 1980s. Initial design work on The Next Step (TNS), the next proposed large fusion reactor after the Princeton Tokamak Fusion Test Reactor (TFTR), will continue and will be used to guide the research program.

BIOMEDICAL AND ENVIRONMENTAL SCIENCES

The traditional role of this program has been the study of biological and environmental effects of radiation in support of the nuclear energy development program, with particular strength in the field of genetic effects of low-level radiation. The program is now expanding to include a broad spectrum of biological and environmental effects of the effluents of alternative energy technologies. In the next few years, continued emphasis will be given to coal conversion and nuclear technologies. A new program in environmental policy analysis will develop critical analyses of environmental issues related to nuclear fuel cycles, coal conversion technologies, and toxic substances. In the latter part of the next six-year period, programs related to geothermal and fusion technologies will expand.

FOSSIL ENERGY

We expect the fossil energy program to be the most rapidly expanding program at the Laboratory over the next six years. The fossil program is roughly 8% of our total 1977 program, and we expect it to approach 15% in six years. Components of the program will include research and development on liquefaction processes, fluid-bed combustors, alkali metal vapor topping cycles, and advanced materials and components for coal conversion systems. Engineering studies, program planning, and environmental impact assessment in support of fossil energy will continue to be important activities of the Laboratory.

CONSERVATION

The conservation program at ORNL is expected to increase substantially in this planning period. The broad program will include modeling of residential, commercial, and industrial energy use; collection and dissemination of conservation data; evaluation and modification of household appliances including heat pumps; process development for recovery of energy from sewage; studies of insulation materials; development of thermal energy storage; cogeneration studies; development and use of flywheels for vehicles and distributed loads; studies of gaseous high-voltage insulators; and work on load management for influencing patterns of electricity consumption. Over the next six years, ORNL will assume increasing responsibility for management of DOE conservation programs

Laboratory Management Organization

In order to direct this diverse multidisciplinary effort, ORNL has adopted a matrix form of organization. Viewed from one direction, the Laboratory is organized into 22 divisions which can each be clearly identified by a service function or an area of disciplinary expertise. Fourteen divisions are technical (e.g., Physics, Chemistry, Engineering Technology, Metals and Ceramics, etc.) and the remainder are service divisions (e.g., Plant and Equipment Division, Health Division, Information Division, etc.). This organizational structure is best suited to guarantee the disciplinary strength of the staff. From another direction, the Laboratory is organized along program lines. At present, these programs include coal technology, gas-cooled reactors, breeder technology, advanced fuel reprocessing, and magnetic fusion energy. These programs involve multidisciplinary teams of physical and life scientists and engineers. The members of the programs are drawn for varying periods of time from the disciplinary divisions. In this way, there exists flexibility without sacrificing the depth of knowledge which results from close involvement with disciplinary activities.

Appendix B is an organization chart of the Laboratory which includes the names of the associate directors and the directors of the various programs and divisions. In Appendix C there is a matrix of the Laboratory activities by division and program.

Lead Roles

ORNL is the principal contractor for the HTGR Fuel Recycle Development Program and is responsible for technical direction of the program, including coordination of activities by other contractors and definition of program requirements. The objective of this program is to develop fuel recycle technology and provide a demonstration facility for the recycle of HTGR fuels on a production basis. Process technology and equipment will be developed to prototype scale and tested in hot engineering tests to confirm the design data required for the recycle facility.

The Laboratory is also the principal contractor for the Advanced Fuel Recycle Program (formerly the LMFBR Fuel Recycle Program). As such, ORNL is responsible for definition of program goals and technical direction of the program, which includes the activities of a number of subcontractors. The program will develop process and equipment technology leading to the design and operation of an Integrated Equipment Test Facility. Design studies for a Hot Experimental Facility, which would demonstrate reprocessing of breeder reactor fuels, will be completed, but the schedule for commissioning the facility has been deferred until the needs are more clearly defined.

The work on Structural Materials for the LMFBR is a planning support function by the Laboratory, under which the national efforts on nondestructive testing and mechanical properties are reported by ORNL and are closely coordinated with related programs in fabrication, corrosion, and high-temperature structural design methods and criteria. This function also includes technical direction of a task on alternative LMFBR structural materials. This area of work involves interactions with several other contractors.

Low-temperature thermal energy storage (LTTES) can help to accommodate the time discrepancy between availability and use for solar, wind, and off-peak electricity. The LTTES Program is aimed at development of both sensible and latent heat storage techniques for temperatures below 250° C to be applied in building heating and cooling systems, industrial processes, and agricultural systems. The program managed by ORNL for DOE is carried out primarily by industrial participants, research institutes, and universities.

The Annual Cycle Energy System (ACES) space heating and cooling system for residential and commercial buildings is designed to balance the energy requirements of a building over a complete annual cycle. The ACES implementation program at ORNL involves system and component research and development, field demonstrations, and dissemination of information.

The use of fluidized-bed coal combustion systems in commercial and industrial applications will make it possible to burn a wide variety of coals, including high-sulfur coal, in an environmentally acceptable manner. The 1.5-MW(t) Technology Test Unit being constructed at ORNL will be operational in 1980. It will serve as a development unit for performance testing and evaluation of the systems for cogeneration applications ranging up to 50 MW(e) with temperatures up to 820° C.

The Superconducting Magnet Development Program has the lead role for designing and testing the magnet systems of tokamaks to be built in the 1980s. The program is divided into two major activities, an ongoing program for basic magnet technology development and the Large Coil Program, which has the specific goal of fabrication and testing of large toroidal-field coils. Several manufacturers are designing and fabricating large coils which will be tested in the coil test facility being constructed at ORNL; this testing will include coils provided by several other nations.

ORNL has responsibility for implementing an integrated program on the assessment of energy effects in the southern portion of the United States as part of an integrated DOE program that covers the entire United States. Our region of responsibility covers 14 states in the Southeast, which collectively represent an energy-rich national resource. The program focuses on national and regional effects of energy development and utilization. Major recent efforts have included analyses of energy use and production in the South and work with the National Coal Utilization Assessment, which has involved all regional participants in the Regional Studies Program and requires an interdivisional, interdisciplinary approach at the Laboratory level.

We have also developed good liaison and relations with energy and other offices within the 14 states and have started to interact on energy and environmental issues to the benefit of all involved.

During the past several years, ORNL has developed a lead role in planning and implementing a life sciences program in support of synthetic fuel development. The program focuses on coal conversion systems, primarily liquefaction, but also includes work related to shale-derived fuels. This interdisciplinary effort utilizes chemists, biologists, ecologists, industrial hygienists, physicians, chemical engineers, and instrument developers. Both the in-plant and out-of-plant environments are of interest from the health, safety, and environmental viewpoints. Chemical and physical characterization of constituents and effluents, process streams, and products of various coal-conversion processes provide the basis for selecting materials to be screened in biological and ecological test systems. Control technology systems using animate and inanimate systems are also developed as part of the program. An iterative procedure allows interactions between the process engineers, the analytical chemists, and the life scientists who test the constituents for cytotoxic, mutagenic, carcinogenic, or teratogenic effects. A major program goal is to assist the developing technology in producing a product and system that will have minimal health and environmental impacts and, therefore, will be more likely to be socially acceptable. This approach provides the opportunity to modify the early development of a process via feedback from the life sciences studies. Current interests are shifting towards specific applications to the Low-Btu Gasifiers in Industry Program.

Planning Assumptions

In developing the long-range projections in this plan, several assumptions have been made:

- There will be very little growth in total personnel full-time equivalents (less than 0.5%/year after 1979).
- The Laboratory will assume increasing responsibility for program management, and there will be an associated increase in the amount of work subcontracted to outside organizations.
- The following growth patterns for programs at the Laboratory, based on changes in personnel levels, were used for post-1979 planning purposes:
  - Strong growth—Coal, Conservation, Solar, Biomedical and Environmental Research and Development,
  - Low growth or diminution—Fusion, Basic Physical Sciences, Petroleum and Natural Gas, In-Situ Technology, Nuclear Physics, Basic Life Sciences Research, Nuclear Energy Development.
- An important consideration in this planning period is the large uncertainty in the future of nuclear energy and, in particular, the breeder programs.

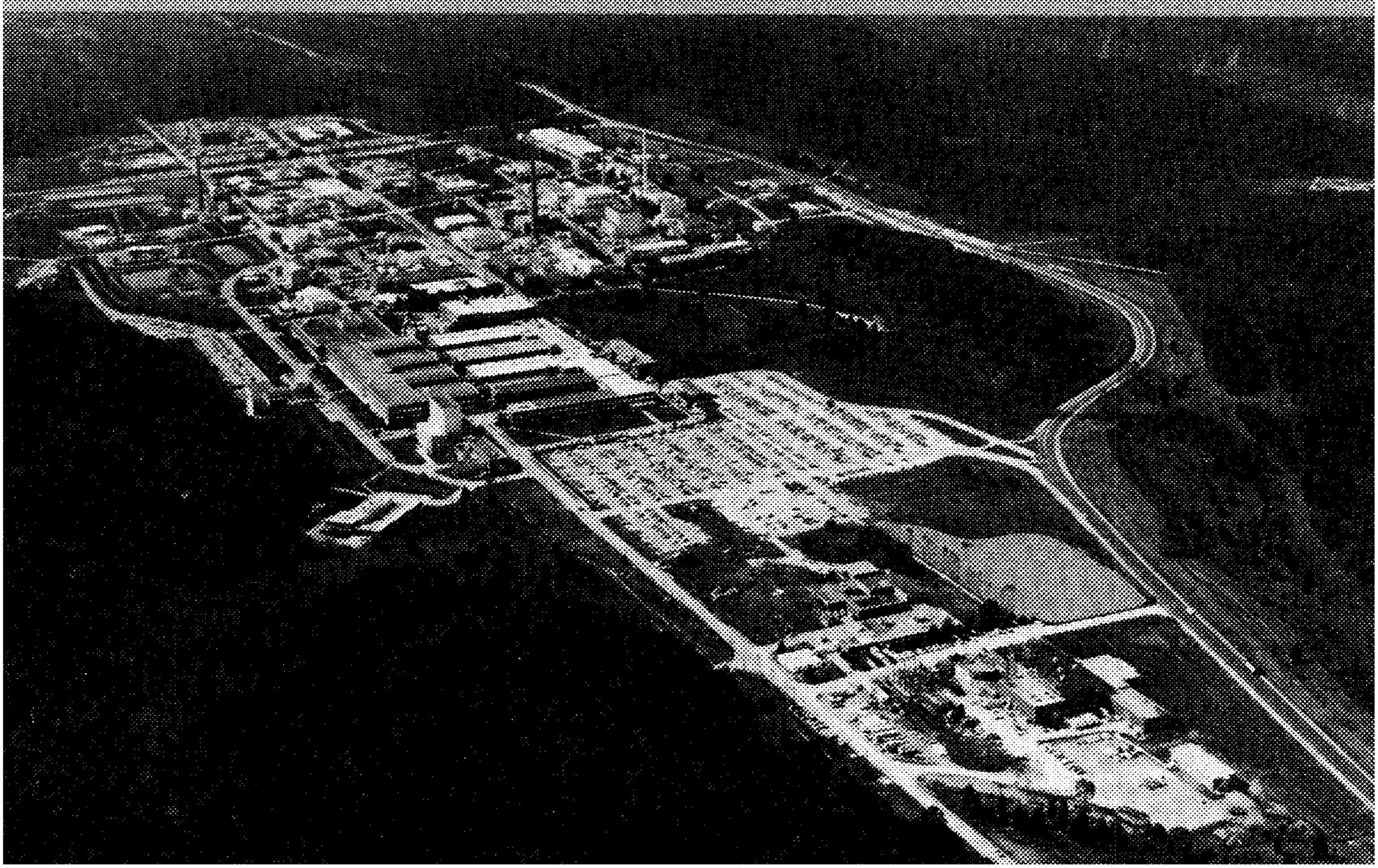
The Laboratory forecasts for operating and manpower levels through 1983 are summarized in Table 1.

Major Planning Issues

The Laboratory faces difficult technical problems in helping to accomplish national goals. Certain issues related to DOE policies and concepts concerning resource allocations will have a strong influence on the Laboratory's success in solving these problems. Some of these are discussed in Chap. 4 of this plan. Stated succinctly, they are:

- Support of special facilities at ORNL (research reactors, accelerators, isotope separators, etc.).
- Funding of general purpose equipment and general plant projects for renovation and addition of laboratory and office space.
- The future of nuclear fuel cycle research and development.
- Management flexibility at the local program level.

Background



2. BACKGROUND

History, Missions, and Areas of Responsibility

From modest beginnings during the World War II Manhattan Project, when its principal mission was the production and chemical separation of the first gram quantities of plutonium, ORNL has emerged as a diversified center of nonnuclear as well as nuclear energy research and development.

Although historically ORNL's major mission had been in nuclear energy development, nonnuclear programs were growing steadily for several years prior to the creation of ERDA in January 1975 and the establishment of DOE in October 1977. Today these activities cover many fields of science and technology, with the focus chiefly on energy production and its environmental and health effects. In addition, ORNL does work sponsored by other federal agencies in areas such as cancer research, environmental assessment, and reactor safety.

Staff specialties—once limited to the physical and life sciences, mathematics, and engineering—now extend into the social sciences and economics. Figure 1 is a summary of manpower levels at the Laboratory and shows the marked decline which took place between 1968 and 1974.

Figure 3 shows a summary of ORNL's operating budget in constant dollars. Eighty percent of the $195 million annual operating budget for FY 1977 was provided by ERDA. Work for other federal agencies, including the Nuclear Regulatory Commission (NRC), National Institutes of Health (NIH), National Science Foundation (NSF), Environmental Protection Agency (EPA), and Department of Defense (DOD), accounts for the remaining 20%.

ORNL's evolution into a diversified laboratory was the result of several factors. New interpretations of the Atomic Energy Act allowed increased flexibility in the laws and regulations regarding the use of national laboratories. At the same time ORNL's management sought to maintain a capable staff whose technical expertise could be applied in nonnuclear as well as nuclear areas to meet national needs.

1948–1960—EARLY HISTORY

ORNL had its beginning early in 1943 as the site for the first nuclear reactor to be operated at power. Soon after the war the Graphite Reactor was converted to produce radioactive isotopes for applications in agriculture, industry, medicine, and research, and for many of the postwar years isotope production was a key function of ORNL. More recently, as private industry has gained the capability for providing these services, the Laboratory's work with isotopes has largely been overshadowed by its broader involvement in energy research and development.

During the 1948–1960 period ORNL carried out various reactor development projects, both military and civilian, within the AEC context. This included major work on the Aircraft Nuclear Propulsion Project, reactor types such as the Homogeneous Reactor Experiment, the development of the "swimming pool reactor," the Molten-Salt Reactor Experiment, and high-temperature gas-cooled concepts. The Molten-Salt Reactor was the world's first to operate on ^{233}U fuel. This program alternately grew and declined through the years and was finally terminated in FY 1976. In addition to the reactor development efforts, ORNL has also done biological radiation research, which has provided information of major significance in setting national radiation standards, and this work expanded into the environmental area.

During the mid-1950s the concept of nuclear fusion began to be investigated. Laboratory physicists who had experience in magnetic fields, ion sources, and accelerator physics from the calutron work at the Y-12 Plant began working on a technology development effort in magnetic mirror fusion. This effort grew slowly until 1970, when the new tokamak concept was adopted. Since then the fusion effort has grown rapidly at ORNL.

1960s—BROADENING RESEARCH AREAS

ORNL did little work for federal agencies other than the Atomic Energy Commission during almost the first two decades of its existence. During the 1960s, however, there were three major areas where the ORNL skill base began to be applied to nonnuclear research. These programs represented a modest departure from ORNL's strictly nuclear expertise to a more broad-based multidisciplinary approach to problems of important national interest. They were the desalting program, which included a basic water research program and a program aimed at developing nuclear-powered desalting plants, the expansion of ORNL's biology research, which involved a multimillion dollar effort between NIH and AEC in basic biological research, and the establishment of the Civil Defense Research Institute at ORNL in 1955 under agreement with the Office of Civil Defense (OCD).

In the late 1960s when environmental problems evolved as a national priority, ORNL's skill base included animal and plant ecology, chemical and radiation mutagenesis, and effluent control studies for nuclear power plants and other sources. ORNL was very interested in applying this expertise as a national resource for facing environmental problems. In 1967 the Atomic Energy Act was amended to provide AEC authority to assist other agencies in solving health and safety problems unconnected with nuclear missions. No major impact of this new authority was reflected at the Laboratory until 1969 and 1970, when the first of a number of interagency agreements were entered into with the EPA and the NSF.

1970s—RECENT TRENDS

In 1970 NSF sponsored a study to investigate how ORNL could best contribute to the growing problems of the environment. General energy work began with energy conservation, energy demand analyses, and the economic and environmental aspects of the coal supply system. These early efforts included work on thermal insulation in residential construction and energy use in transportation. The environmental work included modeling of mercury pathways in the environment and regional modeling, which contributed to ORNL's evolving social science program. The environmental information effort grew into an Environmental Information Systems Office which later became part of the Information Center Complex. Today ORNL is a major national resource in technical information for such fields as basic physical sciences, engineering, biomedical and environmental sciences, energy, socioeconomic studies, and coal technology.

By the early 1970s nonnuclear energy was clearly emerging as a new national policy focus. In 1971 the AEC's authority was further extended to include research on "the preservation and enhancement of a viable environment by developing more efficient methods to meet the nation's energy needs." As a result of the National Environmental Policy Act of 1969 and the Calvert Cliffs decision, the AEC's environmental consciousness was abruptly raised and the AEC was forced to undertake a large impact assessment task. This movement paralleled ORNL's growing competence in environmental research. An Ecological Sciences Division had been formed in 1970, and because of ORNL's ability to mobilize groups to work on this multidisciplinary task the Laboratory was assigned a significant share of the AEC's environmental impact work.

By 1971 ORNL had about $2 million in research and development concerned with nonnuclear energy in addition to its large biomedical and ecological research efforts. Examples of ORNL studies included impacts of central electrical plants, development of methods of absorbing sulfur dioxide (SO_2) from fossil fuels, and design of urban power systems. These were mainly sponsored by the NSF-Research Applied to National Needs (RANN) Program and the AEC. At that time ORNL saw coal studies as an area of major interest. As part of an early long-range planning effort, coal hydrogenation had been explored in the early 1960s during a series of advanced energy seminars at ORNL. Interest in coal research was expressed then, but no funding had been available. However, in 1971 ORNL was asked by AEC to look at SO_2 emissions from the Clifty Creek (Ohio) Power Plant to see if something could be done to meet Ohio's new SO_2 regulations.

The 1973 oil embargo provided additional impetus for funding coal research, and in 1974 ORNL became involved with the Office of Coal Research (a project then classified as work for others) in a joint effort with the AEC. Also in 1974, in order to be in a better position to administer nonnuclear energy programs, ORNL reorganized its internal structure and appointed an associate director for nonnuclear energy research and development.

By 1975, the year in which ERDA was created, much of ORNL's energy work that had been work for other federal agencies became work for ERDA. During the ERDA period ORNL continued to build a broad technical expertise which could be used to support a variety of programs. The newly formed Department of Energy will bring together many elements of the nation's energy policy which had been scattered among several agencies. ORNL management expects to work with the new Department in a coherent and effective manner to carry out energy research and development.

Overview of Technical Resources

LOCATION AND ADMINISTRATION

The Laboratory occupies a wooded, 2900-acre (1200-ha) site approximately 10 miles (15 km) from downtown Oak Ridge, Tennessee (population 29,000). It is one of four major production and research facilities—three of which are located in Oak Ridge—that are operated for DOE by Union Carbide Corporation's Nuclear Division (UCC-ND). The others are the Oak Ridge and Paducah (Kentucky) Gaseous Diffusion Plants and the Oak Ridge Y-12 Plant which, although primarily a national defense installation, also houses some of the ORNL facilities.

Knoxville (population 180,000) is about 30 miles (50 km) away. It is the home of the University of Tennessee, which comprises about 27,000 students, and the central administrative office of the Tennessee Valley Authority (TVA). Also in the Oak Ridge area are the University of Tennessee-DOE Comparative Animal Research Laboratory (CARL), which has extensive whole-body animal irradiation facilities, and the Oak Ridge Associated Universities (ORAU). ORAU administers a number of cooperative programs with universities, through which faculty members and students participate in Laboratory programs for various periods of time.

STAFF AND FACILITIES

ORNL is one of the largest scientific and technological multiprogram laboratories in the world. One of ORNL's strengths is the diversity of the technical staff. Forty percent of the personnel are college graduates, including more than 800 with the Ph.D. degree. There are 800 engineers, primarily chemical, electrical, and mechanical; about 125 mathematicians; 350 chemists; 330 physicists; and more than 300 biomedical and environmental scientists. There is also a growing staff of social scientists, which now numbers more than 35.

The Laboratory population also includes 300 to 400 guest scientists on assignment for periods ranging from a few months to a year or more; many of them represent foreign laboratories or research centers. College and university visitors under a variety of research participation and advanced study programs number approximately 1200 annually; most of them spend between a few days and several months at the Laboratory. This number includes participants in ORNL's University Relations Programs as well as ORAU contractors and ORNL consultants from the university community. In addition to ORNL technical staff and guests, the UCC-ND central organizations that serve all three installations provide a general engineering staff of 1230 and a computer sciences staff of 670 that contribute to ORNL research efforts.

In support of the Laboratory's programs there are facilities and equipment worth $525 million. Figure 4 shows a summary of capital equipment costs in constant dollars. Special facilities at ORNL include:

- An assortment of nuclear reactors ranging from the High Flux Isotope Reactor (HFIR), which produces the world's highest neutron flux, to the Tower Shielding Facility, a reactor that can be suspended in the air for studies of radiation shielding.
- Six particle accelerators engaged in nuclear and atomic physics research, including an advanced electron linear accelerator (ORELA), designed to produce intense short pulses of neutrons for high-precision neutron cross-section measurements, and the isochronous cyclotron (ORIC), which has special capability for accelerating heavy ions.
- The world's largest electromagnetic stable-isotope separation facility.
- A variety of chemical processing development facilities, including the Transuranium Processing Plant (TRU) for separating californium and other heavy elements and the Thorium-Uranium Recycle Facility (TURF) for remotely processing reactor fuels.

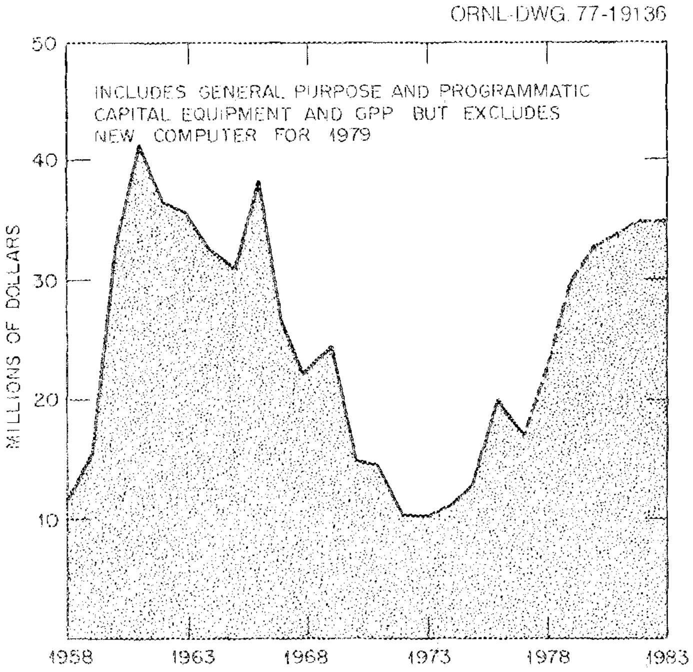


Fig. 4. History of capital costs at ORNL (constant 1977 dollars).

- Two major toroidal fusion energy devices—Impurity Study Experiment (ISX) and Elmo Bumpy Torus (EBT)—as well as a variety of facilities for the development of neutral-particle beams and superconducting magnets.

- An extensive and varied biological laboratory complex, including a Small Animal Facility that can house an experimental mouse population of about 400,000.

- The Oak Ridge Reservation, 38,000 acres of DOE-owned land of which 12,000 acres is currently assigned for long-term ecological experiments, including the Walker Branch Watershed Facility, a well-calibrated natural study area used to investigate the input, transport, fate, and effects of chemical pollutants in a forest ecosystem.

- The Aquatic Ecology Laboratory for studying the effect of water temperature on fish and other aquatic life.

- Extensive materials development facilities, including large laboratory-scale capabilities for purifying, casting, forming, and testing both metals and ceramics.

- A large diversified research fabrication and shop capability for the Nuclear Division complex.

- Extensive Nuclear Division computing hardware for general use, consisting of two large batch high-speed computers (IBM 360/91 and 360/195) and two major time-sharing units (IBM 360/75 and DEC PDP-10) as well as many smaller dedicated computing systems throughout the Laboratory.

- Technical Information Processing facilities which include a major scientific library, computerized on-line access to the major bibliographic data bases in science and technology, and 23 specialized technical information centers which provide rapid state-of-the-art information in a wide variety of fields including physical, engineering, life, and social sciences.

- The Holifield Heavy Ion Research Facility, which, when completed in 1979, will also incorporate the Laboratory's present accelerator, the ORIC.

- The Environmental Sciences Laboratory, which, when occupied in 1978, will be the first laboratory in the nationwide DOE complex designed specifically for environmental sciences research.

INSTITUTIONAL RELATIONSHIPS

Commercialization and Technology Utilization. A diverse research facility such as ORNL can interface with industry in several ways. One way is that in the process of conducting an experiment equipment may be developed that has commercial value. A second interface is through the involvement of private companies in the early stages of design and development of "big" technology. ORNL has been involved successfully with these types of interactions for some years and has attempted to establish working relationships with industry at the earliest possible development stage of new technology. An example of successful commercialization of ORNL research is the zonal gradient centrifuge, which is in wide use in clinical laboratories around the world.

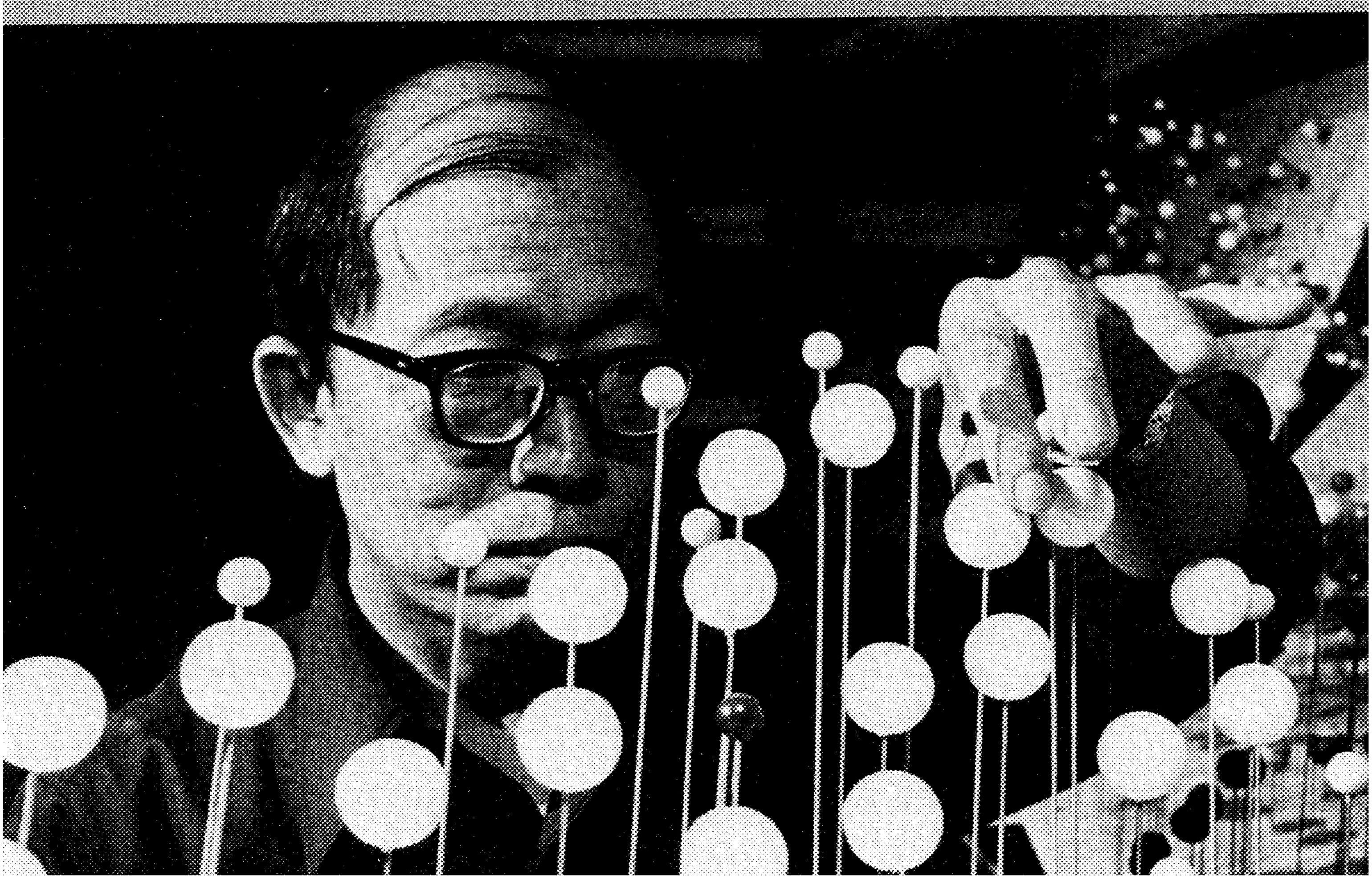
ORNL continues to be closely involved with industry in big technology development, such as development of large superconducting magnets. In the near future, ORNL will become involved with large development projects in the areas of nuclear fuel cycles, fossil fuel utilization, and magnetic fusion energy. Examples of commercialization activities with small-scale technology include ideas such as the Annual Cycle Energy System (ACES) concept, ANFLOW (an anaerobic, upflow, packed-bed bioreactor), and applications of end-use conservation.

In addition to the programmatic efforts that form the basis of technology transfer, the Laboratory also maintains an active program of public awareness of Laboratory developments through press releases and through the publication of technology utilization bulletins. Special workshops and conferences are held under the Technology Utilization and Commercialization program to discuss Laboratory work and to identify the needs and concerns of industry or other user groups, as well as the barriers to their use of such technologies.

University Relations. ORNL has had a long history of cooperation with universities in education and research programs. The Laboratory's primary objective in its university cooperative research and training is to help assure an adequate supply of manpower for the accomplishment of energy research and development programs through activities that complement those of academic institutions. These programs, while providing unique opportunities for cooperative research with the university community, fit within the Laboratory's programmatic goals and simultaneously effect a transfer of scientific and technical information. In FY 1976 ORNL had programs (some of them carried out in cooperation with ORAU) involving 253 undergraduates, 226 graduate students, 28 postdoctoral fellows, and 94 visiting faculty. There are also user groups making use of the major research facilities at ORNL.

Research Cooperation with Energy Utilities. The Electric Power Research Institute (EPRI) is an organization of more than 500 public and private utilities interested in a national electric power research and development program. There is considerable overlap of interest areas between EPRI and DOE. In order that ORNL can most effectively work with EPRI on areas of mutual interest which are consistent with ORNL's mission, a coordinated program has been developed. This program emphasizes active information exchange as well as carrying out some direct research and development work for EPRI. We also foresee a larger involvement with TVA and other energy organizations in the region.

Current and Projected Program Activities



3. CURRENT AND PROJECTED PROGRAM ACTIVITIES

In this chapter we summarize the activities at ORNL discussing, where relevant, the technological thrust of the program, the expected change in its character, any major difficulties or issues peculiar to the given program, and major milestones. The budget figures for FY 1978 and FY 1979 are closely tied to existing financial plans or budgets. The personnel figures are for full-time equivalent personnel and they include support staff. Additional guests are not and cannot be included in the figures because their salaries are not, in general, funded programmatically.

Fossil Energy (B)

TECHNICAL THRUST OF THE PROGRAM

The main thrusts of the fossil experimental program are in coal conversion (particularly liquefaction) and fluidized-bed combustion. ORNL's supporting programs in engineering evaluation and review studies for DOE are expanding to cover all aspects of coal conversion and utilization. A new direction for the fossil program is the management for DOE of an equipment testing program and possibly, in cooperation with the Oak Ridge Operations Office, the management of a fluidized-bed demonstration plant program. In addition, the Laboratory has the leading role in investigating the health and environmental aspects of coal conversion and combustion technologies. ORNL also carries out several activities that support DOE investigations of tertiary oil recovery methods.

MAJOR CHANGE IN CHARACTER OR DIRECTION OF THE PROGRAM

The principal change in direction anticipated in the fossil work at ORNL is the assumption of a management role for DOE in major demonstration programs. The first activity of this nature is the management of a Coal Equipment Test Program (CETP) for evaluating the performance of components for fossil fuel demonstration plants. That may be followed by the technical management of a program to demonstrate utility use of atmospheric fluidized-bed boilers.

The fossil program is expected to have one of the highest growth rates at the Laboratory during this planning period. The internal operating level will double and the management responsibilities for major programs will involve us in larger amounts of subcontracting.

MAJOR RESULTS OR MILESTONES EXPECTED

The major milestones of our three principal experimental programs (Hydrocarbonization, Industrial-sized Fluidized-Bed Boilers, and Alkali Metal Topping Cycles), as well as those for potential demonstration plant projects, are still being negotiated. The following are goals that we suggested to ERDA on the basis of our internal plans:

- We plan to complete bench-scale studies of the hydrocarbonization of Illinois No. 6 coal, renovate the system for operation under flash pyrolysis conditions, and complete high-pressure experiments to provide data that will be of direct use in developing the optimal design of a future demonstration plant.
- We plan to complete an endurance test of our gas-fired potassium boiler to provide a good basis for the scale-up of a natural-circulation potassium boiler if DOE agrees. We also plan to design and construct a prototype fluidized-bed potassium boiler to complete the data collection needed for scale-up of a complete coal-fired alkali metal vapor topping cycle.
- We plan to complete the construction and testing of a Technology Test Unit for an industrial-sized-bed boiler so that industrial firms can take over this program and begin commercial implementation in the mid-1980s.
- We expect to begin a management assistance and technical support role for a 200-MW(e) fluidized-bed combustion demonstration plant and then assist in contractor selection, design, construction, and operation.
- We plan to develop and implement plans for testing critical components for fossil fuel demonstration plants in FY 1978 and conduct supporting work for these components through FY 1990.

Summary of resources—Fossil Energy

	'77	'78	'79	'80	'81	'82	'83
Operating expenses*							
Total Fossil	7.6	14.4	20.0	25.0	30.0	35.0	40.0
BA Coal	6.9	13.7	19.0	24.0	29.0	34.0	39.0
BB Petroleum and Natural Gas	0.6	0.5	0.8	0.7	0.6	0.5	0.5
BC In-Situ Technology	0.1	0.2	0.2	0.2	0.2	0.2	0.2
Subcontracting and procurement on operating expenses*	1.5	4.8	7.1	8.9	10.8	12.6	14.5
Capital equipment*	0	0.3	0.9	3.0	4.0	5.0	6.0
Personnel†	190	220	270	340	400	460	520
Line items							
Energy Systems Research Laboratory (contribution)	$15.1 million, FY 1980 budget						

*Millions of dollars.

†Full-time equivalents.

Solar Energy (EA)

TECHNICAL THRUST OF THE PROGRAM

Our current activities supported by DOE include development of heat exchangers for ocean thermal energy conversion (OTEC), evaluation of solar total energy applications, assistance in applying solar heat in agriculture, assessment of environmental impacts of solar technologies, exploration of advanced concepts for central receivers, application of high-temperature heat to the manufacture of fuels and chemicals, and transfer of solar technology in the South. We also assist in review and surveillance of a 250-kW(e) photovoltaic installation.

Most of the solar supported work at ORNL falls into the areas of analysis, technical support, and evaluation. Our solar experimental research efforts, with the exception of OTEC, are supported by Basic Energy Sciences (BES).

MAJOR CHANGE IN CHARACTER OR DIRECTION OF THE PROGRAM

Environmental assessment is an area in which ORNL is especially well qualified and hopes to assume a greater role in the future. Another area in which our involvement may expand is the application of solar heat to high-temperature industrial processes, especially fuels and chemicals. The work presently includes a survey of applicable processes and an evaluation of engineering and economic feasibility and may later include an experimental program to determine the feasibility of using solar heat in some of the processes.

An area in which we are highly qualified and would hope to develop a larger role is materials research for solar applications. Specific areas include investigation of absorbing coatings for solar collectors, corrosion of crucibles and dies by molten silicon, improving silicon solar cell efficiencies and lifetimes, and corrosion prevention for aluminum used in solar collectors.

ORNL is prepared to assist DOE in the management of their biomass program. Both cultivated and currently wasted biomass should become much more important, and we expect related ORNL efforts in experimentation and management to expand.

In the area of solar heating and cooling, we have concluded that passive solar systems for comfort conditioning of buildings should be emphasized. ORNL is proposing to develop examples of passive designs and to demonstrate the concept in the Southeast.

The probable location of the 1982 International Energy Exposition in Knoxville, Tennessee, will place considerable emphasis on new energy technologies, particularly solar. ORNL's active technical support in developing the exposition may stimulate Laboratory participation in solar-related demonstrations.

MAJOR DIFFICULTIES OR ISSUES TO OVERCOME

The expansion of solar research and the direction of it at ORNL in some respects depends on DOE's particular programs and how the national laboratories can meet those needs. The future also depends on the Laboratory's relationship with the new Solar Energy Research Institute.

MAJOR RESULTS OR MILESTONES EXPECTED

The major accomplishments which are anticipated by the end of FY 1978, based on our present program, include (1) centers for transfer of solar technology established for all southern states, (2) development of a plan and a program for applying high-temperature solar energy to industrial processes, (3) development of a design for a near-ground central receiver concept, (4) doubling of the seawater heat transfer coefficient for the OTEC system, and (5) the successful technical assistance to the photovoltaic-battery storage project at Blytheville, Arkansas.

Summary of resources—Solar Energy (EA)

	'77	'78	'79	'80	'81	'82	'83
Operating expenses*	1.0	1.8	2.6	2.8	3.0	3.2	3.4
Subcontracting and procurement on operating expenses*	0.1	0.6	1.0	1.0	1.1	1.2	1.3
Capital equipment*	0	0	0.1	0.2	0.2	0.2	0.2
Personnel†	28	37	47	53	56	59	62

*Millions of dollars.

†Full-time equivalents.

Geothermal Energy (EB)

TECHNICAL THRUST OF THE PROGRAM

Our current participation in geothermal research is in four areas: (1) heat transfer and power conversion systems, (2) environmental assessments and statements, (3) studies of scale formation in geothermal systems, and (4) corrosion studies. Two of the research areas, corrosion and scaling studies, are being phased out of the program at DOE's request. The corrosion work ended last fiscal year and the scaling work will probably continue only through FY 1978. The low-temperature heat transfer work is expanding with continuation of heat exchanger development. The current thrust is toward scale-up and field demonstration of enhanced heat transfer technologies developed at the Laboratory. Experimental and analytical work is beginning in the area of heat rejection systems as related to geothermal power plants and the direct use of geothermal heat.

The environmental impact work is focused in the near term on generic environmental assessments and statements of the various categories within the DOE geothermal program. The emphasis after the generic assessments are complete will be on impact evaluation for specific facilities, some of which may be associated with the Federal Loan Guarantee Program. The Environmental Assessments project will involve some use of subcontracts to industry and consulting firms under ORNL supervision.

MAJOR CHANGE IN CHARACTER OR DIRECTION OF THE PROGRAM

The low-temperature power systems and environmental impact work described above are expected to continue and expand. In addition, the Gulf Coast geopressured resource poses major energy extraction and conversion questions within the scope of ORNL's interest and expertise. In addition, major environmental questions associated with the resource must be pursued, and the Laboratory is well qualified to do this.

The effects of scaling and corrosion are important areas in geothermal resource development, particularly in assessing the commercial feasibility of such systems. The results of the current ORNL research on formation and control of scale in geothermal systems and the expertise developed may indicate a need for a continuation of the Laboratory's program on scale formation.

MAJOR DIFFICULTIES OR ISSUES TO OVERCOME

A continuing issue for the ORNL geothermal program is definition of a role in relation to DOE's objectives. Our primary talents lie in intermediate-term research efforts. This represents a small fraction of the DOE program which places greater emphasis on early "on-line" power from commercial plants.

The geothermal program has a regional orientation reflecting the regional nature of the resource. Therefore the future expansion or long-term direction of the ORNL program may be tied to the potential of geothermal resources in the eastern United States, primarily the Gulf Coast geopressured resource.

MAJOR RESULTS OR MILESTONES EXPECTED

The low-temperature heat exchanger development work is directed toward the major milestone of field testing a condenser tube bundle at the East Mesa Test Facility during FY 1978. This is to be followed by the construction of a 500-kW(e) demonstration plant, for which the condenser and heat rejection system will be the responsibility of ORNL. In addition, the Environmental Assessments project has a series of milestones for the completion of the generic and site specific assessments.

Summary of resources—Geothermal Energy (EB)

	'77	'78	'79	'80	'81	'82	'83
Operating expenses*	1.0	1.1	1.2	1.5	1.5	1.5	1.5
Subcontracting and procurement on operating expenses*	0.1	0.2	0.3	0.3	0.3	0.3	0.3
Capital equipment*	0.1	0.1	0.2	0.2	0.2	0.2	0.2
Personnel †	30	24	24	31	31	31	31

Magnetic Fusion Energy (ED)

TECHNICAL THRUST OF THE PROGRAM

ORNL has a major role in the national research and development program directed toward designing and constructing a viable fusion reactor. The program at ORNL concentrates on theoretical and experimental studies of toroidal confinement fusion devices with particular current emphasis on the use of neutral-beam injection for plasma heating. The high-beta plasma program is pursuing the Elmo Bumpy Torus (EBT) plasma confinement scheme with the objective of evaluating its feasibility as a fusion reactor concept.

In the area of fusion reactor technology, ORNL has a leading role in the design and development of large superconducting magnets. Fundamental physical research in support of reactor technology is in the areas of properties of materials at high temperatures, neutron cross sections relevant to fusion technology, neutron-induced radiation damage, heavy-ion simulation of neutron radiation damage, and basic chemical and engineering studies relevant to tritium handling.

In addition, programs supported by the Division of Biomedical and Environmental Research are investigating the biological and ecological impacts of tritium in the effluents from fusion reactors.

MAJOR CHANGE IN CHARACTER OR DIRECTION OF THE PROGRAM

Based on a combination of significant developments in plasma physics and fusion technology at ORNL, the program is changing its goal from a marginal low-power-density fusion reactor design to a potentially very attractive design which is about one-half the original cross section. The expected increase in reactor power density results from an ORNL concept for obtaining increased plasma density in a tokamak by rapid neutral-injection heating in time periods which are much shorter than magnetic diffusion times. ORNL's work on radiation damage of materials for the first wall of a fusion reactor indicates that an economically attractive lifetime is possible with these increased power densities. These significant results are now key

Summary of resources—Magnetic Fusion Energy (ED)

	'77	'78	'79	'80	'81	'82	'83
Operating expenses*	32.9	32.0	35.0	38.0	41.0	43.0	44.0
Subcontracting and procurement on operating expenses*	8.8	11.7	10.0	11.0	12.0	12.6	12.8
Capital equipment*	4.0	7.0	5.0	5.0	6.0	6.0	6.0
Personnel †	375	375	380	380	390	390	400
Line items							
Improvements to thermonuclear research supporting facilities	$12.6 million, FY 1980 budget						

elements in an ORNL-industrial design effort concentrating on a tokamak "fusion reactor plasma core." The ORNL experimental and theoretical plasma physics programs are simultaneously combining their efforts with the very advanced technology program to build key experiments to verify these expected high-density plasmas.

The fusion program has been the fastest growing program at the Laboratory in recent years. At present, 15% of the funds are subcontracted and 30% are in device fabrication. The program is expected to continue growing, with a possible increase in the levels of subcontracting dependent on the nature of ORNL's role in major projects in the future.

MAJOR DIFFICULTIES OR ISSUES TO OVERCOME

The major difficulty of the program is obtaining adequate support to build the experimental devices required to verify the crucial plasma-physics predictions. It is necessary to pursue vigorously a fusion reactor design effort but at the same time to continue working on those critical development activities that are essential for implementing the resulting reactor program. ORNL has recently made major contributions in all areas of fusion technology and plasma physics.

The growth of the program has placed severe strains on our 30-year-old buildings and facilities. An FY 1980 line item to begin renovation of these facilities is badly needed.

MAJOR RESULTS OR MILESTONES EXPECTED

Experiments with the ORMAK device, which have reached world record ion temperatures, have verified that neutral injection is a viable heating scheme for tokamaks. Advanced neutral-particle beam lines have been developed and built for the Princeton Large Torus; similar injectors will be used for experimental confirmation of crucial high-density plasma experiments on the Impurity Study Experiment (ISX). This confirmation will be attempted in 1978 after a series of important plasma impurity studies. Additional microwave power is being installed on EBT and proposals for the further extension of the EBT program are being made. In a combined superconducting development program and large coil program, ORNL is working with U.S. industry and with the international fusion community to develop and test half-sized reactor coils by 1980.

High-Energy Physics (EC)

TECHNICAL THRUST OF THE PROGRAM

The high-energy physics program at ORNL is a small one conducted in collaboration with physicists at the University of Tennessee. The focus of the research is on the interaction of high-energy elementary particles with nuclei. The experimental data are collected primarily at Fermilab and analyzed on automatic data-scanning equipment at ORNL.

MAJOR CHANGE IN CHARACTER OR DIRECTION OF THE PROGRAM

The level of effort of this program will remain constant during the planning period.

Summary of resources—High-Energy Physics (EC)

	'77	'78	'79	'80	'81	'82	'83
Operating expenses*	0.4	0.4	0.5	0.5	0.5	0.5	0.5
Personnel†	6	6	6	6	6	6	6

*Millions of dollars.

†Full-time equivalents.

Basic Energy Sciences (EE)

TECHNICAL THRUST OF THE PROGRAM

The Basic Energy Sciences Program at ORNL includes materials research, chemical research, engineering science, mathematics and statistics research, and atomic and nuclear science. These programs comprise both experimental and theoretical work and include a substantial interaction with outside users of basic energy science facilities at ORNL.

The materials research program is a broad-based program in solid-state physics, metallurgy, and materials chemistry. Included are fundamental studies of mechanical, physical, optical, electrical, and magnetic properties.

Such phenomena as superconductivity, radiation effects, diffusion, surface properties, crystal structure, lattice dynamics, and magnetic structure are investigated both experimentally and theoretically. Fundamental knowledge of materials phenomena underlies many materials problems in DOE missions, such as the onset of tertiary creep, photovoltaic conversion, stress-corrosion cracking, and first-wall radiation damage and sputtering in magnetic fusion energy reactors.

The chemical research program covers the range of chemistry disciplines from organic chemistry to chemical physics and atomic and molecular beams. Chemical and physical properties of the transuranic elements are determined. There is a strong program in catalysis because of its fundamental role in coal conversion processes. Aqueous chemistry research provides basic chemical and thermodynamic data on solutions encountered in geothermal systems. Thermochemical, photochemical, and biochemical processes for production of synthetic fuels and the electrochemical properties of fused salts needed for the development of fuel cells and batteries are investigated. Studies of tritium chemical equilibria and permeation are performed as background for the fusion energy program. Analytical chemistry research techniques are developed for identification of the constituents in a wide variety of materials, including noxious by-products of coal conversion processes.

Research in engineering science emphasizes separation with hydraulic cyclones, deep-bed filters, and three-phase fluidized-bed reactors. Mathematics research is directed toward moving-boundary problems, continuum mechanics, statistical methods, and numerical analysis.

The experimental nuclear science program includes basic light-ion nuclear physics, separation of stable isotopes, transuranium element production, and neutron cross-section measurements related to fission and fusion energy technology.

Studies of molecular structure by electron spectroscopy and atomic collisions with slow multicharged ions are important parts of the atomic physics program. Charge exchange and ionization cross-section measurements are important for fusion energy.

MAJOR CHANGE IN CHARACTER OR DIRECTION OF THE PROGRAM

The major change in the direction of these programs will be a continuing shift from research relevant primarily to fission energy technologies to research applicable to fusion, fossil, solar, and geothermal energy technologies. More emphasis will be given in chemistry research to coal-related catalysis studies and to studies of multiphase flow through porous membranes. In materials research, the emphasis will be on properties of materials at very high temperatures in hostile environments. A diversified fundamental research program will be maintained to underlie the research directed toward energy technology.

Summary of resources—Basic Energy Sciences (EE)

	'77	'78	'79	'80	'81	'82	'83
Operating expenses*	28.8	31.6	39.8	39.8[a]	39.8	39.8	39.8
Subcontracting and procurement on operating expenses*	1.1	1.2	1.4	1.5	1.6	1.7	1.8
Capital equipment*	3.0	4.0	6.7[b]	6.0	6.0	6.0	6.0
Personnel†	774	816	961	961[a]	961	961	961
Line items							
Energy Systems Research Laboratory (contribution)	$3.2 million, FY 1980 budget						
High Temperature Materials Laboratory	$24.8 million, FY 1980 budget						

[a] In the absence of detailed guidance from Headquarters we project a constant level of effort beyond FY 1979.

[b] Excluding large computer.

MAJOR DIFFICULTIES OR ISSUES TO OVERCOME

A major issue in this program will be continuing support for the research reactors (the High-Flux Isotope Reactor in particular), and for the existing Tandem Van de Graaff Laboratory. We propose a significant expansion of our effort in the area of materials research at elevated temperatures. This will require significant capital money for major pieces of new equipment. The EN Tandem Van de Graaff Laboratory will not be supported by the Nuclear Physics Program when the Holifield Heavy Ion Facility is operational. Most of the atomic physics discussed here is carried out on the EN Tandem, and significant support for this facility must be provided by the Molecular Sciences Program if the accelerator is to be available.

Nuclear Physics (EF)

TECHNICAL THRUST OF THE PROGRAM

The Nuclear Physics Program at ORNL is dominated by topics related to heavy-ion physics. The present experimental program, using the Oak Ridge Isochronous Cyclotron (ORIC) involves the study of strongly damped collisions (i.e., deep inelastic or quasi-fission reactions). The theoretical physics program is strongly coupled to the experimental program. The present principal area of investigation is gross properties of heavy-ion collisions in hydrodynamic, time-dependent Hartree-Fock, and classical theories. A significant fraction of the Nuclear Physics Program is involved in the development of the Holifield Heavy Ion Research Facility (HHIRF), the central element of which is a 25-MV-on-a-terminal tandem electrostatic accelerator.

*Millions of dollars.

†Full-time equivalents.

Conservation (H)

TECHNICAL THRUST OF THE PROGRAM

The conservation research and development thrust at ORNL has emphasized energy-use management and energy-saving systems, machines, and processes. Designs for more energy-efficient buildings have been an important activity. The buildings work includes analyses and experimental investigation of heating and cooling systems and of the efficiency of various appliances. The experiments have involved gas furnaces, water heaters, room air conditioners, and a complete mobile home; the present emphasis is on heat pumps. New systems are being developed with the goal of commercialization. The Annual Cycle Energy System, ACES, is in the demonstration test phase.

A new sewage treatment process, ANFLOW, which has been under development at the Laboratory for more than two years, is currently being operated as a pilot demonstration in cooperation with the city of Oak Ridge and the Norton Company.

Summary of resources—Nuclear Physics (EF)

	'77	'78	'79	'80	'81	'82	'83
Operating expenses*	5.0	5.4	6.5	6.5[a]	6.5	6.5	6.5
Subcontracting and procurement on operating expenses*	0.2	0.2	0.2	0.2[a]	0.2	0.2	0.2
Capital equipment*	0	0.5	0.5	0.5[a]	0.5	0.5	0.5
Personnel†	154	158	176	176[a]	176	176	176
Line items							
Addition to ORIC building	$4.5 million, FY 1981						
Holifield Heavy Ion Research Facility, Phase II	$25.0 million, FY 1979						

[a] In the absence of detailed guidance from Headquarters we project a constant level of effort beyond FY 1979.

Summary of resources—Conservation

	'77	'78	'79	'80	'81	'82	'83
Operating expenses*							
Total Conservation	4.4	11.2	14.3	17.3	18.0	18.6	19.1
HA Electric Energy Systems	0.6	3.2	4.0	4.0	4.0	4.0	4.0
HB Transportation Energy Conservation	0.3	0.4	0.5	0.6	0.6	0.6	0.6
HC Energy Storage Systems	0.8	1.7	2.0	3.5	3.8	4.0	4.0
HD Buildings and Community Systems	1.9	5.0	6.0	7.0	7.0	7.0	7.0
HF Conservation Research and Technology	0.3	0.2	0.8	0.9	1.0	1.0	1.0
HG Industrial Energy Conservation	0.5	0.7	1.0	1.3	1.6	2.0	2.5
Subcontracting and procurement on operating expenses*	1.5	7.0	9.1	11.6	11.8	12.0	12.2
Capital equipment*	0.1	0.1	0.3	1.0	1.0	1.0	1.0
Personnel†	94	97	155	167	181	196	208
Line Items							
Energy Systems Research Laboratory (contribution)	$3.2 million, FY 1980 budget						

An expanding role for ORNL in conservation research and development is program management for DOE. Technical and managerial assistance in program planning and implementation is currently being provided in several areas: (1) low-temperature thermal energy storage, (2) residential and commercial appliances, (3) ACES, (4) electrical load leveling, and (5) performance of insulation materials.

Two of ORNL's more fundamental conservation research projects are (1) gaseous insulators, which will allow higher-voltage electrical transmission systems, and (2) studies of the physical chemistry of high-temperature fuel-cell electrolytes, which can lead to more efficient generation of electricity.

Another category of conservation research and development at ORNL has been created by studies to establish performance standards and methods of testing for thermal insulation.

The Laboratory is developing computer models which simulate the demand for fuels by sector, region, and end use. These models are used to assist DOE and state governments in evaluating energy conservation policies, technologies, and strategies. ORNL is a center for the collection of data related to energy use, and information is provided to DOE and other agencies by the publication of energy conservation data books. The first volumes were on transportation energy conservation, and a data book on energy conservation in buildings is nearing completion.

MAJOR CHANGE IN CHARACTER OR DIRECTION OF THE PROGRAM

An important dimension of ORNL's conservation efforts is the management of research and development programs for specific DOE-Conservation divisions. This activity is expected to grow and expand into other areas. Electric load management by improved end-use technology and improved thermal insulation materials are recent additions.

Research and development related to the use of reject heat from power generation is carried out in three ORNL divisions. Cogeneration of electricity and use of condenser heat for industrial processes, district heating and cooling, and aquacultures have an important conservation potential. Reclaiming minerals from coal ash appears to offer conservation potential and is being studied at ORNL. Development of high-temperature refractories to enable industry to switch from gas to heavy oils is ORNL's major undertaking in industrial conservation.

ORNL has proposed a major expansion of research, development, and demonstration in industrial energy conservation for FY 1978. The program includes analyses and experiments in the following areas: (1) demonstration of the energy conservation potential in optimizing preparatory operations for pyroprocessing, (2) development of refractory materials for high-temperature recuperators, (3) development of low-cost nontoxic brazing alloys and solders for economic waste- and process-heat exchangers, and (4) development of low-loss transformer materials.

MAJOR RESULTS OR MILESTONES EXPECTED

One of the major accomplishments of the ORNL conservation program in the next year will be testing of the ACES concept in a variety of installations. In the residential and commercial appliances program, our efforts toward development of higher-efficiency appliances will result in commercialization of one or more of the improved appliances by FY 1980. The energy demand models for residential and commercial sectors have already been used in the ERDA and FEA planning processes. We expect similar use to be made of models of fuel demand by the industrial sector. Transportation data books have been issued, and books on buildings will be following.

Reports will be issued in FY 1978 on the results of materials and insulation studies, including an assessment of materials for high-temperature recuperators; evaluation of test procedures for thermal insulations; and, in 1979, an evaluation of industrial refractories with heavy oil as a fuel; coal will be considered later.

Nuclear Energy Development (K)

TECHNICAL THRUST OF THE PROGRAM

In support of the national effort on development of energy sources from fission reactors, the Laboratory will continue to concentrate on perfecting fuel cycle technology and will emphasize the evaluation and assessment of alternative fuel cycles, particularly as regards safeguards, security, and resistance to proliferation. The development of base technology on reactor physics and materials, high-temperature design, and safety of fast breeder reactor systems will also continue to receive high priority. The program will evaluate approaches to the management of radioactive wastes derived from the fuel cycle, such as stabilization in cements and actinide partitioning.

The fuel cycle development effort will support the concept of safeguarded nuclear energy centers, which would comprise fast breeder reactors and reprocessing facilities, and a system of power reactors outside the center that would be supplied with denatured fuel from the energy center. This program would develop and demonstrate the technology for reprocessing and refabrication of denatured thorium-cycle light water reactor-heavy water reactor (LWR/HWR) and high-temperature gas-cooled reactor (HTGR) fuels and the reprocessing of low-enriched HTGR fuels. Technology development for the gas-cooled fast reactor system will expand substantially because of the commitment to design and commission a facility, the Core Flow Test Loop, in which simulated fuel bundles will be tested under design transient and accident conditions. Related technology development programs on breeder projects, isotopic power systems, and the HTGR are expected to increase only slightly.

MAJOR CHANGE IN CHARACTER OR DIRECTION OF THE PROGRAM

Fuel cycle development activities are being sharply redirected to the study and support of proliferation-resistant fuel cycles in response to the Administration's decision to reduce the emphasis on use of plutonium in breeder reactors and the recycle of plutonium for use in LWRs. The program on breeder reactor fuel cycle will include the uranium-233/thorium cycle as well as the plutonium/uranium cycle, and emphasis in thorium fuel cycle studies will shift to denatured fuel cycles for use in LWRs and HWRs and to denatured or medium-enriched fuel for use in the HTGR. Development activities on these fuel cycles will be closely coordinated with the assessment and evaluation of the nonproliferation aspects of various cycles.

In addition, the Laboratory completed a preliminary study on the feasibility of accelerator breeding and submitted a proposal for further work in recognition of the substantial benefits that could accrue if the fast breeder reactor programs are seriously delayed. Although another laboratory may be chosen for the lead role in this work, ORNL will in any case assist in supporting invesitgations as is appropriate.

MAJOR DIFFICULTIES OR ISSUES TO OVERCOME

A major problem to be addressed will be the political and institutional acceptance of denatured and low-enriched fuel cycles as being

Summary of resources—Nuclear Energy Development

	'77	'78	'79	'80	'81	'82	'83
Operating expenses*							
Total	49.8	62.4	76.5	83.0	85.0	82.0	79.0
KG Breeder Reactor Program	12.2	12.0	14.0	16.0	17.0	16.0	16.0
KJ Nuclear Research and Applications	11.2	16.4	19.0	20.0	18.0	16.0	16.0
KX Fuel Cycle Research and Development	22.2	27.5	35.0	41.0	45.0	45.0	42.0
KZ Special Materials Production	4.2	6.5	8.5	6.0	5.0	5.0	5.0
Subcontracting and procurement on operating expenses*	9.9	13.6	19.9	26.1	26.8	25.9	25.1
Capital equipment*	6.8	8.7	14.6	14.0	13.0	12.0	11.0
Personnel †	1102	1215	1430	1570	1515	1455	1405
Line items							
Advanced Fuel Recycle Program Integrated Prototype Equipment Test Facility (IPET)	$15.4 million, FY 1979 budget						
Title I and II design of Hot Experimental Facility (HEF)	$50.0 million, FY 1980 budget						
HTGR Fuel Recycle Hot Engineering Test Facility (HET)	$30.0 million, after FY 1979						

Nuclear-Energy-Related Work for Other Agencies

	'77	'78	'79	'80	'81	'82	'83
Operating expenses*							
Nuclear Regulatory Commission	16.0	18.0	20.0	20.0	20.0	20.0	20.0
Other federal agencies	9.0	6.0	7.0	6.0	6.0	6.0	7.0

equally resistant to proliferation as the present LWR low-enriched fuel.

MAJOR RESULTS OR MILESTONES EXPECTED

In the Advanced Fuel Recycle Program (1) the Integrated Prototype Equipment Test Facility (IPET) is to be operational in 1981, and (2) complete conceptual design of Hot Experimental Facility (HEF) is to be prepared for line-item budget submission in 1980. In the HTGR Fuel Recycle Program, conceptual design of the Cold Prototype Test Facility (CPTF) will be completed in 1979 and construction of the facility will begin in 1982.

Environmental Research and Safety (R)

TECHNICAL THRUST OF THE PROGRAM

The overall biomedical and environmental sciences program funded through the RK (Environmental Research and Development) and RV (Life Sciences Research and Biomedical Applications) subprograms at ORNL is primarily concerned with the identification, understanding, and reduction of health and environmental impacts of energy production and utilization. Research activities in this program include physical, chemical, biological, ecological, health, and assessment studies on the transport and effects of products and by-products of both nuclear and nonnuclear energy technology at the molecular, cellular, organism, population, and total-system levels.

The RK subprogram activities are oriented toward specific technologies, whereas the RV subprogram activities are oriented toward a more basic understanding of those biological phenomena which apply more broadly across technologies and have longer-range payoffs.

Specific objectives in the biomedical and environmental studies include development of a basic understanding of interactions of specific products and by-products with biological systems, application of this understanding to evaluation and assessment of observed transport and effects, and prediction of potential beneficial and detrimental impacts of energy production and utilization through an integration of available information and mathematical simulations. Advanced instrumentation is being

*Millions of dollars.

†Full-time equivalents.

developed at both basic and applied levels to ensure that potential energy-related pollutants can be monitored adequately.

The Decontamination and Decommissioning subprogram (RU) is a continuing effort to respond to requirements for radiation surveillance.

There have been three major changes in ORNL efforts in the biomedical and environmental areas. First, in response to DOE's new interest in environmental policy analysis, ORNL set up an Office of Environmental Policy Analysis as part of the DOE program. Second, in the area of toxicological effects research, the Laboratory's strategy has shifted toward developing a strong major program. Third, ORNL has made a shift in our program for early detection of environmental health effects to emphasize epidemiological techniques.

While we do not anticipate any major problems in our technology-related research funding, as indicated by our projections in the accompanying budget summaries, we are concerned over the apparent plateau of funding in the basic life-sciences research area. It will be difficult and unwise to increase our level of effort in the nonnuclear research and development area by additional reprogramming from our nuclear research and development effort.

Also in the area of budget allocation, costs related to safeguards requirements may preclude further use of the Health Physics Research Reactor unless additional programmatic support is obtained.

ENVIRONMENTAL RESEARCH AND DEVELOPMENT (RK)

DOE has the responsibility for creating energy choices for the future that are economically sound, socially acceptable, and in accord with health, safety, and continuing acceptablity in environmental quality. Environmental policy issues concerning fuel cycles have been directed to DOE for analysis, evaluation, and judgment. The Office of Environmental Policy Analysis was established in ERDA to deal with current and future policies related to the development and utilization of energy and to provide inputs for decision-making by DOE management and higher councils of government. Each multipurpose laboratory has established an Office of Environmental Policy Analysis. In this program, ORNL has been assigned responsibility for performing critical issue analyses of criteria, land use, and institutional arrangements for control of solid wastes from energy technologies, with particular emphasis on the Resources Conservation and Recovery Act; decontamination and decommissioning criteria for inactive uranium mill tailings sites and excess DOE sites; and water and energy development policy issues in the eastern United States.

In cooperation with other DOE laboratories, we are participating in the National Coal Utilization Assessment and expect completion of the first-year assessment of environmental, social, and economic impacts of coal extraction and utilization through the year 2000 in the Southeast. Through the Environmental Policy Analysis Office we expect to assist DOE in dealing with current and future policies related to the development and utilization of energy and to provide inputs for decision making by DOE management and higher councils of government.

We have developed a comprehensive program to investigate basic ecosystem processes. Through integration of these processes we can conduct assessments of the impacts on the environment of effluents from specific energy technologies. The activities encompass both the coal and nuclear fuel cycles, including low-level waste management. Future efforts will deal with the transport and behavior of effluents from geothermal energy and nuclear fusion as these technologies are developed. The program will involve a broad range of studies from experimental work on poorly understood ecosystem models to field studies of actual impact.

In the search for new energy sources, some previously unknown biological hazards are likely to surface. These hazards must be identified rapidly so that corrective action can be taken before exposure of the general population occurs. Major research programs are involved with the development of genetic and somatic testing systems designed to screen animal populations for a variety of potentially hazardous substances.

Toxic effects will be the first detrimental health effect that will be detected in humans from occupational or environmental exposures to energy sources and their by-products. Many of the techniques that were developed during the past 30 years to study the risks to human well-being from exposure to radiation are also applicable to estimating the risk to humans from chemicals. However, there are some special problems, such as identifying the chemicals and mixtures of chemicals of interest, determining the methods of exposure to them, determining the dose received, and correlating the effects with risk to human health. The solution of these problems requires development of new procedures.

New initiatives are being taken in interdisciplinary programs in biotechnology and bioengineering. The development of bioprocesses useful in the areas of energy production, resource recovery, conservation, and pollution abatement will become increasingly important. Investigations will include activated-sludge reactors for process waste treatment and bioconversion to fuels, abatement of pollution due to organic contaminants in the effluents of coal conversion processes by bioreactors that use immobilized enzymes or microorganisms, coal beneficiation and resource recovery by slurry reactors that use microorganisms, and removal and concentration of dangerous heavy-metal pollutants or resource materials from dilute aqueous streams by using bioreactors.

Another part of the program aims to provide information necessary for ensuring that processes for converting coal to synthetic fuels will not result in unacceptable risks to human and environmental health when they are implemented on a large commercial scale. The development of this coal converion technology should proceed in such a way that conversion processes can be optimized not only economically but also for maximum protection of human and environmental health. Therefore, biomedical and environmental research must proceed in concert with technological development.

Research activities in this program can be divided into two broad classes: those designed

Summary of resources—Biomedical, Environmental, and Safety Research

	'77	'78	'79	'80	'81	'82	'83
Operating expenses*							
Total Biomedical, Environmental, and Safety	26.0	28.0	30.0	32.0	34.0	35.0	37.0
RK Environmental Research and Development	18.4	20.0	21.0	23.4	24.8	26.4	28.0
RU Decontamination and Decommissioning	0.3	0.5	0.8	0.9	1.0	1.1	1.3
RV Life Sciences Research and Biomedical Applications	7.3	7.4	8.0	8.0	8.0	8.0	8.0
Subcontracting and procurement on operating expenses*	1.3	1.2	1.8	2.0	2.0	2.1	2.3
Capital equipment*	1.5	1.8	2.3	3.0	3.0	3.0	3.0
Personnel†	825	886	906	982	1035	1084	1134
Line items							
Energy Pollutant Control System (Super GPP)	$1.9 million, FY 1978 budget						
Toxicology Laboratory (Super GPP)	$1.5 million, FY 1979 budget						
Addition to Aquatic Ecology Laboratory (Super GPP)	$1.5 million, FY 1980 budget						
Toxic Substance Laboratory and Animal Facility	$11.5 million, FY 1980 budget						
Information Resource Center for Energy and the Environment	$10.0 million, FY 1980 budget						
Mammalian Genetics Facility addition to Building 9210	$4.5 million, after FY 1980						

Environmental-Research-Related Work for Other Agencies

	'77	'78	'79	'80	'81	'82	'83
Operating expenses*							
NRC (includes impact statements)	2.0	2.5	3.0	3.0	3.0	3.0	3.0
Other agencies[a]	11.0	13.0	13.0	14.0	14.0	14.0	15.0

[a]Includes work for HEW/NIH (NCI, NIAID, NLM, NIEHS, NIGMS), FDA, EPA, NSF, et al.

*Millions of dollars.

†Full-time equivalents.

to provide information on intact effluents and fractions thereof through use of rapid toxicity screening tests and those that utilize model compounds and are designed to elucidate mechanisms of effects, metabolic degradation pathways, persistence, bioaccumulation potential, and ultimate fate. Research for evaluating the potential hazards to man and his environment are proceeding from initial toxicity screening tests to chronic exposure and environmental transport and fate studies. Links have been established with the Energy Research Centers (Pittsburgh, Laramie, and Morgantown) and with industry for obtaining samples for initial chemical and biological screening. To facilitate this research, techniques are being developed for chemical profiling and multicomponent analysis of selected compound types. A production activity is being implemented to provide well-characterized materials for biological and environmental research. The health effects portion of the program will involve tests for toxicological, carcinogenic, mutagenic, and teratogenic effects of products and effluents. Emphasis will be on screening tests using multiple test systems in laboratory animals. Chronic effects studies on important components of the environment will be conducted at the organism, population, and community level.

Major anticipated results in the Biomedical and Environmental Research Program include: the development of rapid, reasonably accurate early detection and screening techniques for health effects arising from synthetic fuel production; more efficient methods for assessing impacts of energy technology products and by-products on our environment; a more thorough understanding of the mechanisms governing carcinogenic and mutagenic effects of chemical and physical agents; and development of advanced methods of energy by-product deactivation through the concept of bioreactors.

LIFE SCIENCES RESEARCH AND BIOMEDICAL APPLICATIONS (RV)

Much of the work in the General Life Sciences subprogram underlies the more specific, technology-oriented activities in the RK programs. Development, validation, and improvements of the systems for testing new biological hazards is supported by research efforts in carcinogenesis and mutagenesis. The problems relating to toxicological effects will require the acquisition of new knowledge on which to base identification, dosage, and source of the materials involved.

The objectives of the Biomedical Applications Program are to provide the maximum possible contribution to national health goals and to serve the needs of the biomedical community through various approaches.

During the past few years the major focus of this program has been on radionuclide systems for early detection of disease, radiopharmaceuticals, radiation detection systems, and nuclear medicine instrumentation. The trend toward techniques for measuring dynamic functions will enhance sensitivity for detecting early pathophysiology and provide tools for determining the metabolic parameters for pollutants of concern to energy technologies. Improvements are also being pursued in the techniques for preparing and separating isotopes.

DECONTAMINATION AND DECOMMISSIONING (RU)

The decontamination and decommissioning work at ORNL is a continuing effort to respond to DOE requirements for radiation surveillance within the installation. It has three major phases:

1. Long-term radioactive surveillance of surplus contaminated facilities.
2. Formulation of plans for disposing of such surplus facilities.
3. Actual decommissioning work.

Similar work is carried on for the NRC.

Although not yet reflected in budget numbers, ORNL would like to begin a $1.2 million phase-three effort to decommission the Fission Product Development Laboratory.

Institutional Relations (UB)

UNIVERSITY RELATIONS

Major Thrusts. The Laboratory's primary objective in its university cooperative research and training programs is to help ensure an adequate supply of manpower for the accomplishment of energy research and development programs through activities that complement those of academic institutions. These programs, while providing unique opportunities for cooperative research with the university community, fit within the Laboratory's programmatic goals and simultaneously effect a transfer of scientific and technical information. To achieve the program objectives, a multifaceted approach is employed, dependent on the academic level of the participants from the university community. This includes undergraduate science semesters in cooperation with the Great Lakes Colleges Association and the Southern Colleges and Universities Union, co-op and pre-co-op programs with various engineering schools, and a program with the Carnegie Foundation for training minorities in the biological sciences. At the graduate level ORNL has a cooperative research quarter with the MIT School of Chemical Engineering Practice, a cooperative research program with the University of Tennessee ecology program, on-the-job training for industrial hygiene interns, and the University of Tennessee-Oak Ridge Graduate School of Biomedical Sciences, which is a doctoral degree granting program. In the area of postdoctoral research, ORNL has the Eugene P. Wigner Fellowship program for exceptional postdoctoral candidates as well as a significant postdoctoral program through the Biomedical Graduate School. Finally, ORNL has faculty participation programs, which provide university faculty the opportunity to use our unique research facilities, and the faculty institute in Applied Health Physics, which trains college professors who return to their institutions to establish curricula in health physics-related areas.

In addition to ORNL administered programs, the Laboratory cooperates with the Oak Ridge Associated Universities (ORAU) in many of ORAU's student education programs.

Major Difficulties. Adequate funding is a major problem in the development and maintenance of our university relations programs, many of which have to be partially supported by other sources. At present we receive only $153,000 (through subprogram UB), a substantial cutback from FY 1976. This came at a time when we were expanding our Great Lakes Science Semester Program and in addition experienced a general cost-of-doing-business rise of about 7%. If we are to maintain our present level of activity, some accommodation is needed.

TECHNICAL INFORMATION

Major Thrusts. ORNL has a major Technical Information Program amounting to over $6 million. However, most of the activities are integrated into and funded through various DOE technical program offices. In the UB support subprogram ORNL has funding for two relatively small projects. These are the development of data element description standards and support for a Deskbook on Energy. The descriptions of the major information activities funded through other DOE subprograms are contained in the appropriate Chapter 3 subprogram and in the chapter on centers of interprogrammatic expertise.

Summary of resources—Institutional Relations (UB)

	'77	'78	'79	'80	'81	'82	'83
Operating expenses*	0.2[a]	0.2	0.2	0.2	0.2	0.2	0.2
Personnel†	4	4	4	4	4	4	4

[a] In the absence of detailed guidance from Headquarters we project a constant level of effort.

Regional Activities

We expect the Laboratory's interactions with other organizations in the Southeast, including the Tennessee Valley Authority (TVA) and state energy offices, to increase in the future. Examples of current work with a regional emphasis include the Coal Utilization Assessment, analyses of energy use and production in the South, and the Solar Energy Technology Transfer Program. Many of the ongoing environmental programs are related to organizations and institutions outside the Oak Ridge area.

Users of Research Facilities

The unique research facilities at ORNL are used by visitors from universities, other national laboratories, and industrial laboratories. Many of them engage in collaborative experiments with ORNL scientists and all carry out research relevant to the DOE/ORNL missions. Facilities frequently used by outside researchers include the High Flux Isotope Reactor (for material irradiations and neutron scattering experiments), the electron and ion accelerators, and x-ray equipment for crystallography and small-angle scattering.

†Full-time equivalents.

Summary of resources—Work for Others

	'77	'78	'79	'80	'81	'82	'83
Operating expenses*							
Total	38.4	40.0	42.0	43.0	43.0	44.0	44.0
Program 40—reimbursable work for other federal agencies							
NRC	17.9	20.4	22.8	22.8	22.8	22.8	22.8
HEW	4.9	5.8	6.2	6.4	6.6	6.8	7.0
EPA	2.0	2.3	2.1	2.1	2.2	2.2	2.3
NSF	1.2	1.8	2.2	2.3	2.3	2.4	2.5
Others	3.2	1.7	1.0	1.0	1.0	1.0	1.0
Program 41—cash work for other DOE contractors	2.0	1.5	1.4	1.7	1.7	1.7	1.7
Program 42—DOE transfers	6.3	5.5	6.3	6.3	6.3	6.3	6.3
Program 43—work for other UCC-ND installations	0.9	0.7	0.5	0.3	0.3	0.3	0.3
Personnel†	1020	1050	1120	1130	1140	1140	1150

*Millions of dollars.

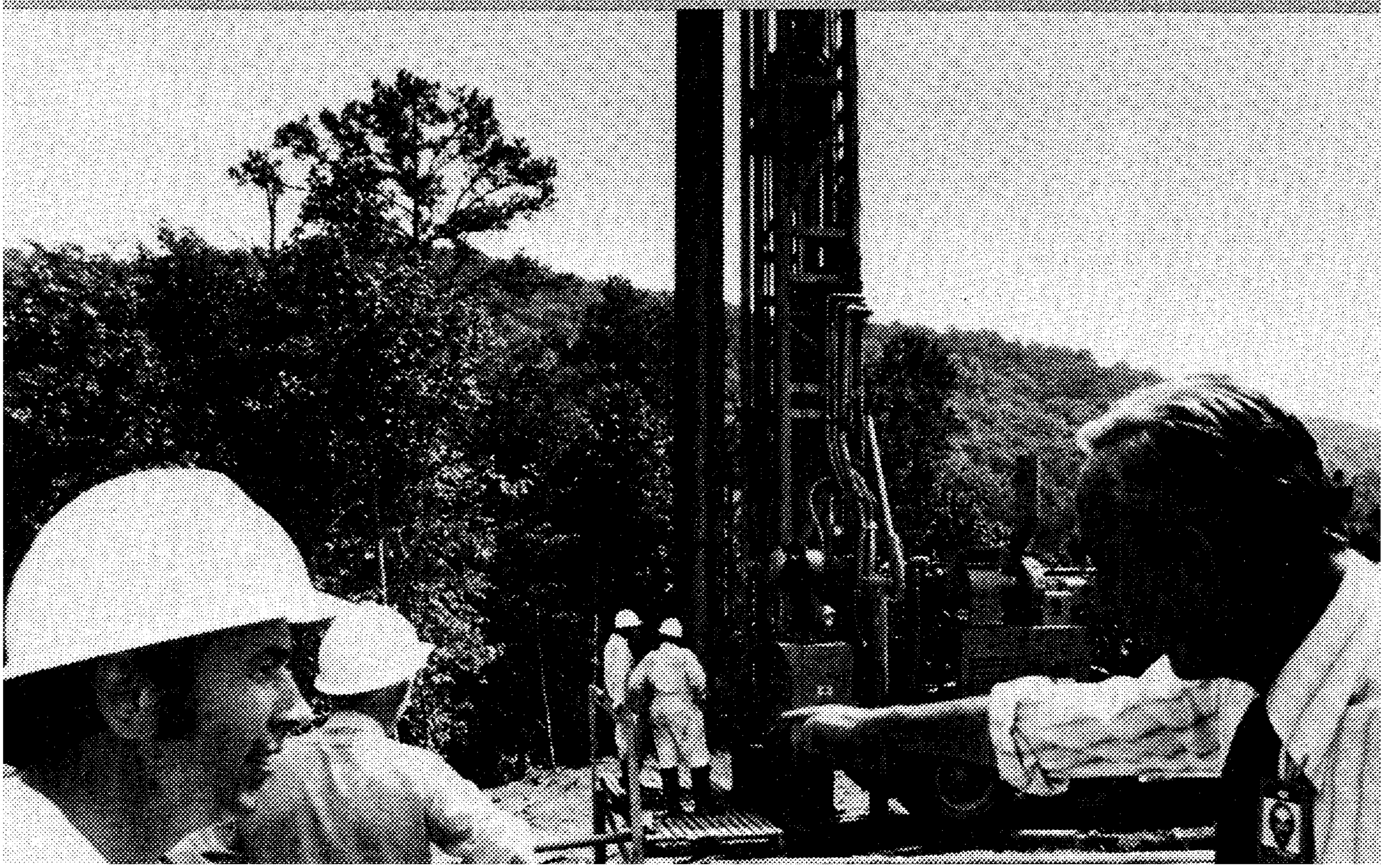
†Full-time equivalents.

Work for Others

The Laboratory has substantial, and very valuable, programs for other federal agencies. Approximately half of this funding comes from the Nuclear Regulatory Commission (NRC), most of it from the Reactor Safety Research Division of NRC. The next largest sponsor is the Department of Health, Education, and Welfare (HEW), followed by the Environmental Protection Agency (EPA) and the National Science Foundation (NSF). It is expected that NSF and HEW programs will grow somewhat faster than those for EPA.

Capital equipment acquired in the course of work for others is included in the operating budget.

Institutional Resource Requirements



4. INSTITUTIONAL RESOURCE REQUIREMENTS

Table A-1, in Appendix A, shows a summary of total operating expenses at ORNL for the period FY 1977 to FY 1983. Tables A-2.1 and A-2.2 give details of extramural expenditures; projections of personnel numbers are shown in Table A-3. Tables A-4 and A-5 summarize funds and proposals for, respectively, capital equipment and construction.

Computer Equipment

The projection of computing capability needed at ORNL and at the other plants comprising the Oak Ridge site is shown in Fig. 5. The existing batch computing facilities were saturated at the end of 1976, and it is expected that a major new system will be installed late in FY 1979.

The interactive capability was greatly oversaturated, but with the addition of a PDP-10 KL-10 central processor in FY 1977, adequate interactive computing is presently available, although it will again be saturated by FY 1980.

The largest users of the batch computing facilities at ORNL are the Neutron Physics and Fusion Energy divisions. It is expected that they will still be the largest users in FY 1982. Perhaps the greatest uncertainties in the projections arise from the impact of relatively young programs in fields like environmental and health sciences and information processing, which have a large potential for growth.

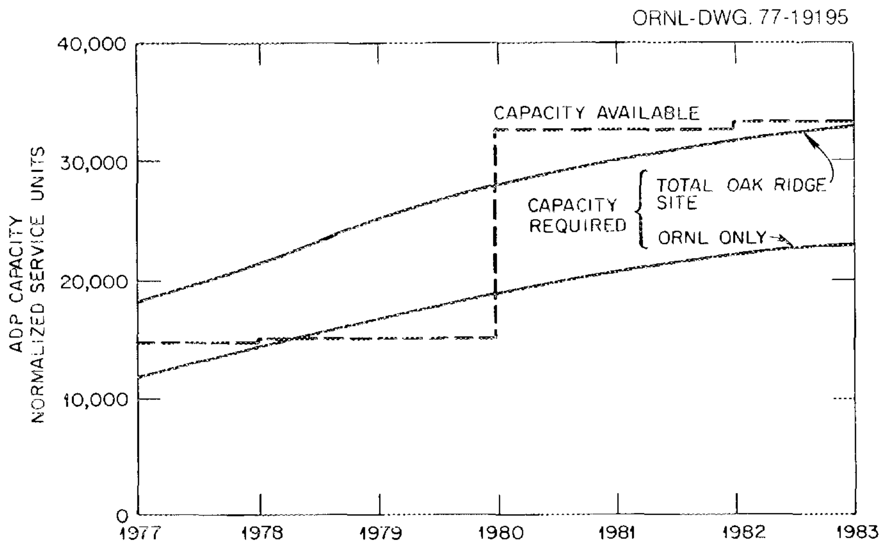
Projected needs and the computer acquisition schedule indicate that there will obviously be a significant computer shortage over the next several years. A temporary solution over the next 1 to 2 years will be to shift some of the load to computers at other installations (Idaho Falls, Savannah River, Berkeley) which are not yet saturated.

The proposed new computers in FY 1979 will cost approximately $10 million but may well be leased. Included in the new system will be the devices needed to meet on-line storage requirements, particularly for interactive information retrieval from energy-related data bases.

Addition of Space

Our office space is insufficient for the present staff—over 800 of our office users are overcrowded (have less than 75 ft² each), and an additional 1100 are in offices of substandard quality (offices that are old and deteriorated; in attics, basements or trailers; or are noisy, etc.). The laboratories are inadequate for our present needs. Much of the space dates from World War II, and few laboratories have been added since the early 1960s. Because of changes in the nature of our programs, the laboratories often do not meet present requirements for height, floor loading, safety, isolation, temperature control, cleanliness, etc. We anticipate some

Fig. 5. Requirements and capacity for automated data processing.



growth in staff and programs in coming years, much of it in the nonnuclear programs, so that our needs for different or special kinds of experimental space will become even more acute, despite the relief granted by the completion of the new Environmental Sciences Laboratory.

The situation is represented in Table 2. The major proposed items involved are the Energy Systems Research Laboratory, the High Temperature Materials Laboratory, and the Information Resource Center for Energy and the Environment. It is important to note that the space shortages are not solely a consequence of projected growth in ORNL staff, which is extremely small. We need more space to accommodate adequately the staff which we *now* have.

Our priorities, after computers, are for the Energy Systems Research Laboratory, general plant construction funding (including conservation projects), and funding required to comply with OSHA regulations.

Support of Special Facilities

We have already alluded to the problem of obtaining continuing support for facilities which have interprogrammatic and, in some cases, interagency applications. The research reactors (especially the High-Flux Isotope Reactor) are one type of such facilities, and the existing Tandem Van de Graaff Laboratory is another. The tandem will not be supported by the DOE Nuclear Physics Program when the Holifield Heavy Ion Facility is operational, and significant support must be provided if it is to continue to be available for atomic physics research.

Personnel

For the period 1979–1983, the Laboratory's full-time scientific and technical personnel are expected to increase at a rate of less than 0.5% per year. This, coupled with an expected annual turnover rate of approximately 5% per year, will result in hiring activity of the order of 5–6% per year. The mix of scientific and technical personnel is expected to show an increase in engineering disciplines, particularly in the fossil fuel area. The number of social scientists is expected to increase markedly. Modest increases in the number of basic physical scientists and environmental scientists are expected. The number of research and development personnel working in fusion energy and in life sciences research is expected to remain approximately constant. Increasing emphasis will be

Table 2. Personnel distribution by facility type

Laboratory forecast[a]

Facility type	1977	1978	1979	1980	1981	1982	1983
Temporary	1900	1831	2072	2087	2177	2148	1643
Permanent	1705	1705	1965	1965	2009	2053	2558
Proposed new facilities		260[b]		44[c]	44[d]	505[e]	165[f]
Total office persons[a]	3605	3796	4037	4052	4186	4201	4201
Total population[a]	5778	6056	6328	6468	6543	6617	6625

[a]Personnel numbers given include guests and visitors who require office space.

[b]Environmental Sciences Laboratory, Holifield Heavy Ion Facility, general plant projects.

[c]Toxicology Laboratory, Integrated Equipment Test Facility, Oak Ridge Isochronous Cyclotron.

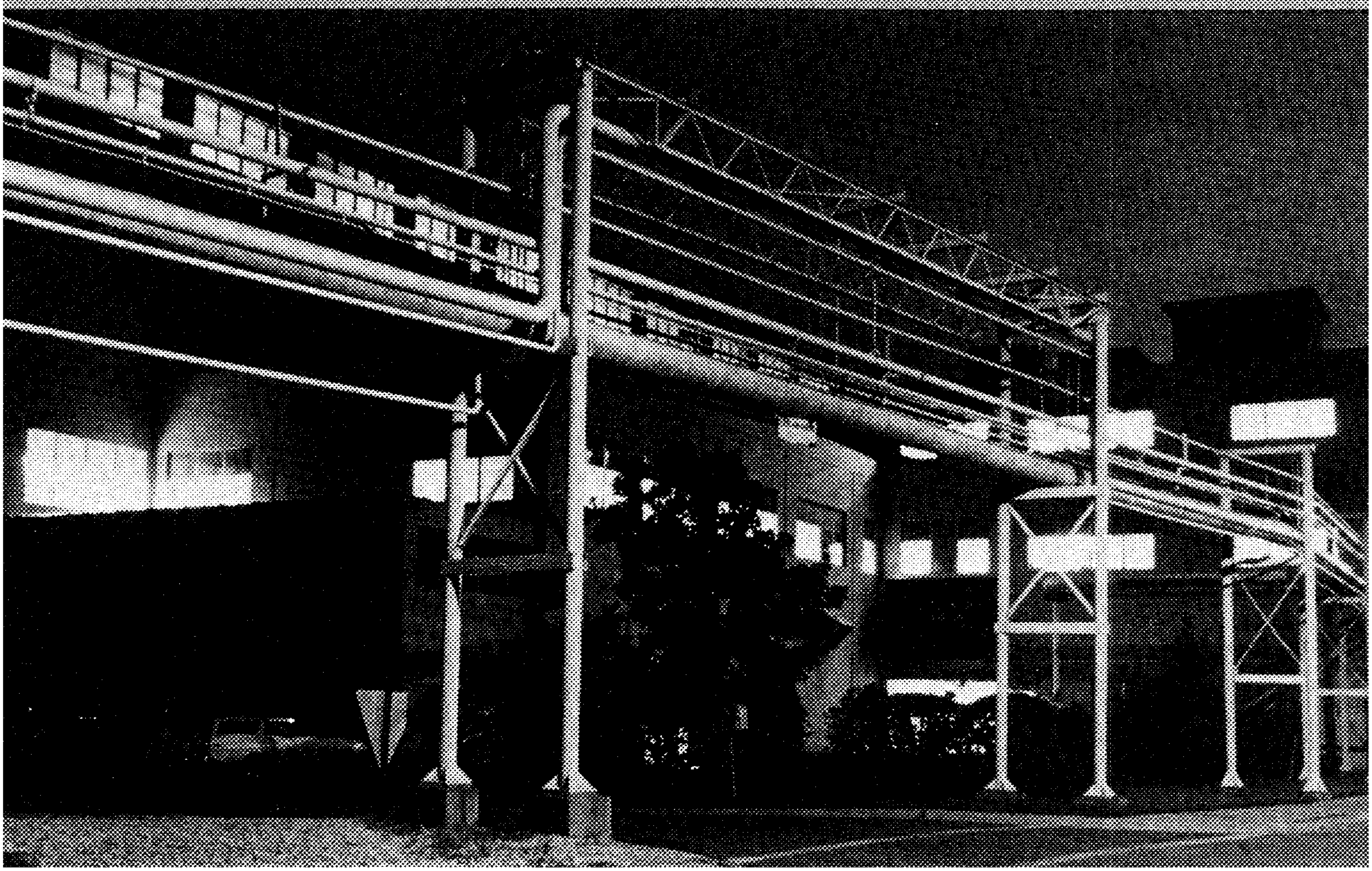
[d]Aquatic Ecology Laboratory.

[e]Energy Systems Research Laboratory, High-Temperature Materials Laboratory, Toxic Substances Laboratory, and Animal Facility.

[f]Information Resource Center for Energy and the Environment.

placed on the use of initial temporary appointments for new employees, particularly in the basic physical and life sciences areas. Increasing difficulty in attracting top-flight engineers, reflecting the national supply/demand situation, will likely occur. The Laboratory will continue to pursue, both in policy and practice, its strong commitment to affirmative action.

New Initiatives



5. NEW INITIATIVES

In this chapter, we discuss some major new initiatives which, if funded, would have a significant effect on the Laboratory's activities. In addition to these specific proposals it is appropriate in this chapter to give a brief description of the Laboratory's ongoing "seed money" program.

Seed Money Program

This program is the means by which ORNL research staff can pursue new and innovative ideas that cannot immediately be integrated into existing projects and that show promise of ultimate funding by DOE or other agencies. Proposals for funding under this scheme are reviewed by a committee at ORNL and, if approved, may receive support from the resources allocated to the Seed Money Program. The program was inaugurated in 1974 to support up to 14 man-years of effort and has continued at about the same level. It is projected that by the end of the current financial year, the returns to DOE and other agencies (i.e., the amount of new work initiated) will exceed the outlay on Seed Money projects:

Seed money outlays and returns (man-years)

	'74	'75	'76	'77	'78	Total
Estimated Outlays	9	14	14	13	13	63
Estimated Returns			11	25	34	70

Future success from the Seed Money Program may be limited by allowable ORNL growth, so that extrapolation of the rate of growth of benefits beyond FY 1978 would probably be too optimistic. However, new proposals continue to be submitted at a rate comparable to the past, and participants among the research staff continue to be optimistic about initiating new, externally funded projects.

High-Temperature Materials Laboratory (HTML)

Almost all energy technologies involve the generation of heat. A major problem of all these technologies will be the availability of materials with appropriate properties at elevated temperatures. Materials may be the decisive factor in a technology for reasons of economy as well as efficiency and reliability. The new HTML would be a unique laboratory for basic research on materials at elevated temperatures, including dedicated precise measurements and very long term (100,000-hr) experiments. It would be organized for a variety of interdisciplinary studies. A large inventory of materials-testing equipment already exists at ORNL which would be incorporated in the new laboratory with extensive new equipment. The estimated expenses for building and equipping HTML are:

Building (80,000 ft^2)	$18.3 million
Equipment and moving expenses	6.5 million
	$24.8 million

It is estimated the staff of HTML would include about 65 professionals, about 20 to 25 of whom are at ORNL. We proposed HTML as a line item in FY 1979, but it was not included in the budget. We are submitting it for the FY 1980 budget. Discussions on this proposal have been held with the Materials Science Program in the Division of Basic Energy Sciences. A conceptual design report has been prepared.

Fusion Energy—The Next Step and Long Pulse Technology Tokamak

ORNL proposed to ERDA's Division of Magnetic Fusion Energy (DMFE) that a major responsibility for the design and the necessary supporting research and development program for TNS (The Next Step) be assumed by Oak Ridge's Fusion Program. The goal of the TNS program is to operate a fusion reactor core—a long-lived, ignited deuterium-tritium plasma—by the late 1980s, with the simultaneous development of necessary support technologies. The site would probably not be ORNL.

As a result of the TNS activities, ORNL has identified the need for a Long Pulse Technology Tokamak (LPTT) as an interim device to provide integrated systems experience for the implementation of TNS. The LPTT would be a superconducting hydrogen device with a pulse-length capability of tens of seconds. This device would be operational in the early 1980s and would be constructed at ORNL.

Discussions with DMFE concerning the implementation of the LPTT are currently under way.

Solar Energy—Biomass

ORNL has proposed a management role in DOE's biomass program. We have considerable background and existing programs in forest ecosystem physiology, biophotolysis, resource economics, and land-use analysis related to biomass production, as well as background in bioprocess development including pilot plant design, installation, and operation, which would be useful in managing a biomass program for DOE.

The Carbon Dioxide Problem

The increased use of fossil fuels and various land-use practices over the last century have contributed to an increase in the atmospheric concentration of carbon dioxide (CO_2) and have caused concern at the national and international levels. At some level of CO_2 concentration the "greenhouse" effect can lead to significant changes in the earth's climate. These changes can, in turn, affect land use in a number of ways. Since the use of fossil fuels is proposed to increase significantly in the coming decades, it is imperative that we develop a good understanding of the CO_2 cycle. There are three general areas which have been identified as crucial: (1) how CO_2 is distributed in the biosphere, (2) what climatic changes could result from CO_2 buildup, and (3) the environmental impacts of these changes.

We propose to contribute to a broad-based program of research and assessment of the CO_2 problem. Discussions have been initiated with DOE's Division of Biomedical and Environmental Research regarding the extent of this involvement, and a comprehensive research and development proposal has been submitted to NSF as part of an ongoing program in ecosystems science. We would conduct research in three areas of the CO_2 problem:

1. Modeling the carbon cycle in the biosphere. We already have extensive experience in terrestrial ecosystem analyses and are almost a sole source of much of the needed data. We will continue the terrestrial studies, and we are starting work on atmospheric and aquatic ecosystem modeling.
2. Climatological modeling. We would rely extensively on expertise at the National Oceanographic and Atmospheric Administration, the National Center for Atmospheric Research, and Oregon State University in this field, although we hope to develop enough competence locally to do some of our own modeling and to interact usefully with these existing group programs.
3. Impact research and assessment. There is very little effort in this area at present; we propose to play a major role. Our experience in this field gives us unique capabilities for impact studies. Particular emphasis would be given to risk analysis of CO_2 buildup and to sensitivity analysis of those parameters in the model which may have highly uncertain values.

Lead Role in Reactor Fuel-Cycle Assessments

As a result of recent presidential directives on plutonium fuel reprocessing and the new emphasis on susceptibility to proliferation, the next two years will be a period of intensive study and evaluation of alternative fuel cycles. We propose to assume a lead role in this program because:

- ORNL already has lead roles in the Advanced Fuel Recycle Program and the High-Temperature Gas-Cooled Reactor (HTGR) Fuel Recycle Development Program. Much of the fuel reprocessing chemistry and many refabrication techniques were developed at ORNL. Thus we have extensive experience in critical areas of these fuel cycles.
- ORNL operates a facility that has been designated as a repository for the nation's supply of ^{233}U. Experience in recovery, processing, and safeguarding the material has been invaluable.
- We have an ongoing and diverse reactor-assessment group that has participated in such assessments for about 20 years.

We propose to assume management roles in evaluating the relative acceptability of the possible fuel cycles for advanced converters and breeder reactors. These evaluations of the fuel cycle and reactor concepts include such factors as reactor physics, resource utilization, fuel cycle and capital costs, safeguards, and vulnerability to diversion and proliferation. Some of the evaluation work will be subcontracted to industry, universities, and other national laboratories where possible. Initial discussions of this program have been held with the DOE divisions involved in nuclear energy programs.

Lead Role in Measurement and Control Sciences

We propose that ORNL be assigned the lead role in management of the previously dispersed and considerably neglected area of measurement and control (frequently called I&C, for "instrumentation and control"). Although measurement and control are integral parts of virtually every technological discipline, there is a need for coordination of the many I&C activities related to energy generation and conversion, safety, component and materials testing, and fuel reprocessing. Pertinent activities at ORNL encompass all aspects of development, modeling, design, construction, installation, and maintenance of measurement and control systems. In addition, there are groups concerned with electronic circuit development, digital systems and pulse techniques, radiation detection, process and analytical instrumentation, and metrology. Design requirements and performance criteria for measurement and control systems would be coordinated closely with industry and contractors that are responsible for particular applications.

Lead Role in Technology of Containment Systems

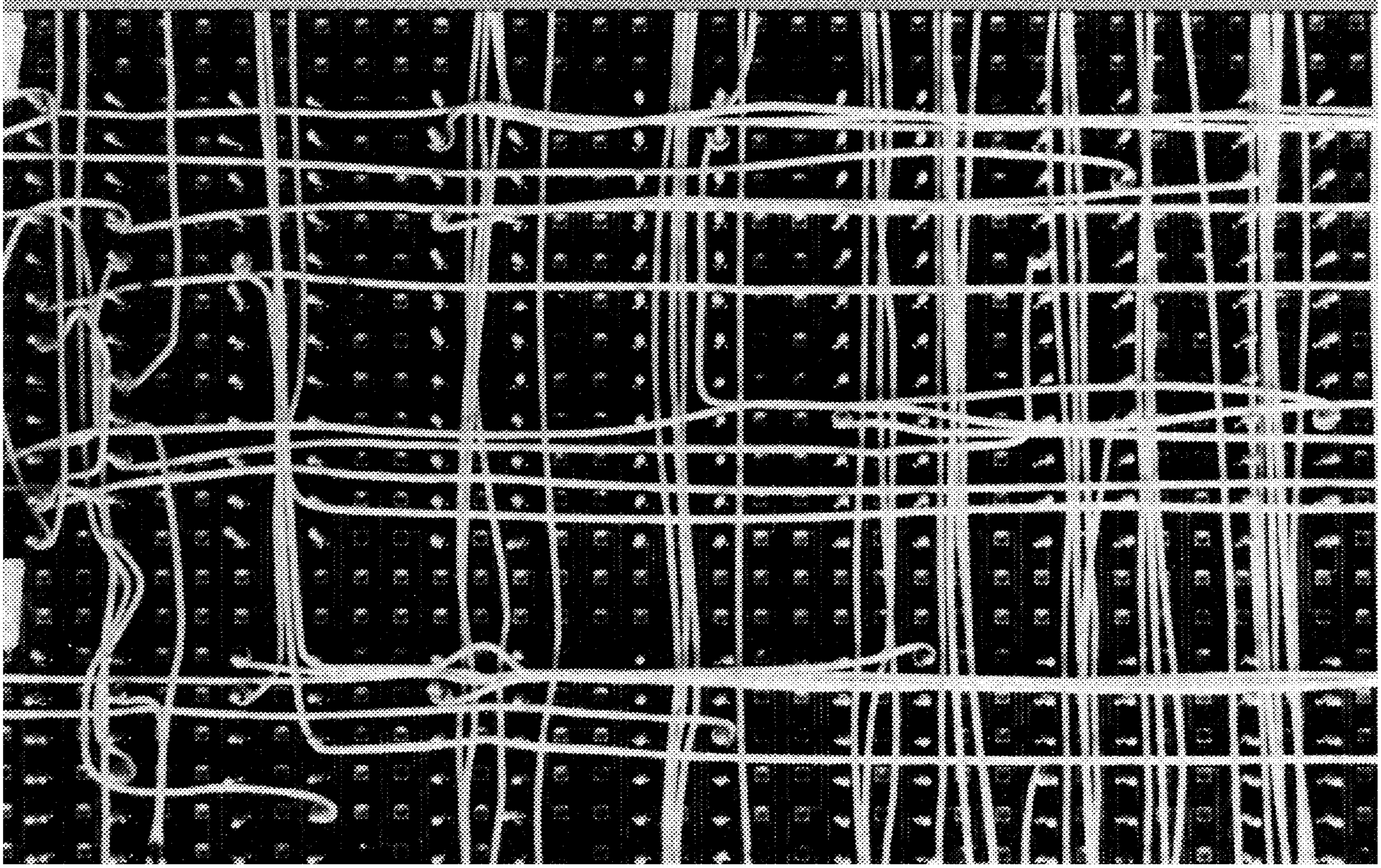
The development of prestressed concrete reactor vessels (PCRVs) as pressure containment systems for nuclear reactors and other energy-related purposes is receiving significant support, particularly for gas-cooled reactors and coal conversion systems. For about 10 years ORNL has been heavily involved with materials selection, modeling, testing, and analytical studies of PCRVs for the HTGR and Gas-Cooled Fast Reactor (GCFR) programs and has conducted feasibility studies on vessels for other applications. Thus we propose that PCRV technology be designated as a major task area for development of containment systems and that ORNL be assigned the lead role in this area. The strong participation by industry in design studies and by university subcontractors in analytical and testing efforts would be an important ingredient of the program.

Holifield Heavy Ion Research Facility, Phase II

The Phase II project would expand the Holifield Heavy Ion Research Facility (HHIRF) to provide the higher-energy beams (at least 12 MeV per nucleon for the heaviest elements and at least 100 MeV per nucleon for lighter elements) to support a broad spectrum of national research programs in nuclear physics, nuclear chemistry, atomic physics, and materials science. A separated-sector cyclotron (SSC) with an ion energy capability of approximately 400 q^2/A MeV will be the central item in Phase II. This $K = 400$ SSC will be arranged to provide a second stage of acceleration for ion beams from both the 25-MV tandem and from ORIC.

The facility will be designed as a national facility with the capacity to support a large user organization. The total project cost for Phase II is estimated to be $25.0 million. A conceptual design report has been prepared, and the project was proposed for the FY 1979 budget.

Major Areas of Interprogrammatic Technical Expertise



6. MAJOR AREAS OF INTERPROGRAMMATIC TECHNICAL EXPERTISE

By their nature, the multiprogram laboratories tend to have broadly based areas of expertise which underlie many aspects of their programmatic work. Discussed briefly in this chapter are some of these broad areas at ORNL. It is interesting to note that, overall, these fields receive a high proportion of their support from agencies other than DOE.

Materials Technology

The ultimate commercial success of many of the new energy sources will depend critically on the availability of appropriate materials, particularly materials with acceptable properties at elevated temperatures and in corrosive environments. One of ORNL's traditional and major roles in nuclear fission reactor technology has been in the area of materials development and testing. As the matrix in Table 3 indicates, this competence has been redirected and expanded to consider materials problems related to fossil and solar energy technologies as well.

The areas of activity at ORNL include: radiation effects on metals and alloys; basic physical investigation of clear and absorbate surfaces; studies of the deformation characteristics of metal oxides; fracture and creep studies; high-precision measurements relating to physical transport properties; surface reactions on alloys in mixed-gas, high-temperature environments; electrochemical studies of corrosion mechanisms; aqueous chemistry at elevated temperatures; joining technology and alloy development for materials in steam generators; development work on fabrication of components for large systems; and development of large prestressed concrete vessels for coal conversion techniques.

The staff involved in these programs are mechanical, civil, nuclear, electrical, and chemical engineers; metallurgists; ceramicists; chemists; and physicists. Special facilities at ORNL which are particularly useful to these projects include three research reactors (the Oak Ridge Research Reactor, the High-Flux Isotope Reactor, and the Bulk Shielding Reactor); a 1-MeV electron microscope; low-pressure, high-temperature refractory furnaces; a small-angle x-ray scattering (SAXS) facility with a 10-m spectrometer; and the Oak Ridge Isochronous Cyclotron (ORIC) for heavy-ion bombardments of materials.

One of the new initiatives discussed in this *Institutional Plan* calls for the development of a High-Temperature Materials Laboratory which would be devoted to this area of research and would include a considerable amount of highly specialized and precise equipment for materials testing.

Nondestructive Testing Techniques

Nondestructive testing development activities are conducted in the Metals and Ceramics Division. The current program has a wide variety of tasks, including substantial programs on the development of techniques for the examination of stainless steel welds, steam generators, pressure vessels, and graphite and fuel pins. Techniques for coating and failure analysis are also under development. Work is being carried out for DOE, the Nuclear Regulatory Commission (NRC), and the Navy. In the past, other sponsors involved have included the National Aeronautic and Space Administration (NASA), Bureau of Mines, the Department of Defense, Atomic Energy of Canada, Ltd., and private industry.

Inspections using nondestructive methods are performed by the Inspection Engineering Department at ORNL, but this effort is not included in the matrix in Table 3.

Measurement and Control Technology

ORNL has an Instrumentation and Controls (I&C) Division which acts partially as a service organization to other divisions at the Laboratory and in this way participates in a number of DOE programs. In addition, it receives funding from the Nuclear Regulatory Commission. However, the effort which arises directly from I&C represents only a fraction of the Laboratory's activities and expertise in this area. Most of the experimental programs require a substantial

Table 3. Sources of support for major interprogrammatic technology areas, FY 1977

Technology area	Direct man-years[a]	Operating cost (millions of dollars)											
		Fossil Energy (EA, BB, BC)	Solar Energy (EA)	Physical Research (EC, EE, EF)	Magnetic Fusion Energy (ED)	Conservation (HA, HB, HC, HD, HF, HG)	Fission Reactors (KG, KJ, KX)	Uranium Resources, Special Materials Handling, Waste Management (KY, KZ)	Environmental Research and Development (RK)	Institutional Relations, Support Activities (UB, UC)	Non-DOE	Overhead	Total
Information systems	185	0.1		0.6	0.3	0.3	0.3	0.1	0.9	0.2[b]	3.5	1.1[c]	7.4
Materials technology	385[d]	0.7	0.6	11.6			2.9						15.8
Measurement and control technology[e]	30[f] ~100[g]												
Nondestructive testing technology	15	0.2					0.6				0.4		1.2
Catalysis and surface science	33			1.8	0.5				0.1				2.4
Social and economic analysis	65	0.2	0.2	0.2		0.5	0.1		0.6		3.1		4.9

[a] Full-time equivalents.
[b] Includes funding for information support activities from the UCC-ND Computer Sciences Division.
[c] Includes library and specialized information services.
[d] Estimated.
[e] Approximately 5–15% of the majority of experimental program activities fall in this category.
[f] Staff within the Instrumentation and Controls Division.
[g] It is estimated that approximately 100 staff members outside the Instrumentation and Controls Division are engaged in this activity.

effort on instrumentation, and this is often supplied by staff members who are not in the I&C Division. In this way, the expertise is diffused throughout the Laboratory, as indicated in Table 3.

Catalysis and Surface Science

A vital component of the basic energy sciences program at ORNL is the catalysis program in the Chemistry Division. The work presently is focused on processes associated with coal combustion and conversion, but it clearly has wider applications.

Molten salts are being used as homogeneous catalysts for steam-coal reactions and for cracking and hydrogenating carbonaceous materials such as coal, tars, and hydrocarbon fuels. Basic research is in progress to characterize the various salts as catalysts, to determine potential materials problems which might arise from the use of molten salt catalysts, and to understand the fundamental processes in homogeneous catalysis. In the area of heterogeneous catalysis, the chemistry of heteroatom removal from coal and the basic processes involved in the desulfurization of coal by heavy-metal sulfides are being studied. These programs presently involve 8 to 12 chemists who are already coordinating aspects of catalytic processes related to various methods of hydrogen production. These aspects should be relevant to both the fossil and solar energy programs. Surface science research is a broad program at the Laboratory, with substantial efforts under way in seven divisions. Most of this research is supported by the Division of Basic Energy Sciences, but there is also significant funding from the Division of Magnetic Fusion Energy and a small program in the Division of Environmental and Biomedical Research. The work is guided by the need to understand surface properties and behavior in heterogeneous catalysis, plasma-wall interactions in magnetic fusion, and mechanical behavior. Experimental studies include Auger spectroscopy, positive-ion crystallography, sputtering, ion implantation, and ion microprobe analysis.

Social and Economic Analysis of Energy Systems

A cadre of social scientists including economists, sociologists, political scientists, and geographers are employed in a wide variety of energy system analyses and assessment projects. These projects are funded by a number of divisions of DOE and by other federal agencies including NRC and the Department of Commerce. The work includes (1) the preparation of environmental statements and assessments for NRC and DOE; (2) the assessment of the social, economic, and resource effects of various energy futures at a regional level for the Division of Technology Overview; and (3) the development and application of engineering-economic models for forecasting the effects of policy decisions and technological changes on the demand for fuels by various sectors of the economy. The third type of work is done for DOE, NRC, and the state of California. In addition, advanced computer graphics systems have been developed for analyzing such varied problems as power plant siting, coal resource estimation, and strip mining impact assessment. In support of these socioeconomic and resource analysis activities, ORNL has developed and collected extensive data bases which describe energy supply and demand; resources; the transportation system; environmental characteristics; and social, economic, and demographic characteristics at various levels of spatial and temporal resolution.

Information Systems and Services

Oak Ridge National Laboratory has a unique combination of computer processing capability, technical expertise, and information-science experience. The Laboratory has the most extensive complex of scientific data and information-analysis centers in the United States, with 21 active centers supporting DOE programs in engineering, the physical sciences, biomedical and environmental sciences, socioeconomics, and conservation. In FY 1977 there were 150 salaried staff working in these centers (including 72 technical specialists), with an operating budget of about $5.6 million.

To support information processing, analysis, and evaluation activities, ORNL has on-line access to 93 national and international abstracting and indexing services, which cover more than 30 million citations to the technical literature. The UCC-ND Computer Sciences program, which supports ORNL's information work, includes development and maintenance of RECON (DOE's national bibliographic retrieval network) and an extensive generalized software system for technical information processing known as ORCHIS.

This combination of facilities and technical subject knowledge gives ORNL a special expertise in producing state-of-the-art reviews and critically evaluated data. Special recognition has been gained in the areas of environmental and biomedical contaminants, nuclear safety, radiation shielding, nuclear structure data, and high-purity research materials.

ORNL believes that there will be a growing need in DOE's programs for fast, reliable, and relevant information analysis and retrieval; increasingly, the programs and solutions that are being identified require interdisciplinary capabilities, which depend heavily on the analysis and synthesis of information from various fields. Because of the importance of this work, ORNL's information activities have recently been analyzed and programmatic responsibility for technical information centers has become more highly focused. A major new proposal known as the Information Resource Center for Energy and the Environment will be submitted for FY 1980 funding. This would establish an information sciences laboratory, where ORNL's combination of information and technical expertise could be physically integrated to create a state-of-the-art problem-solving environment.

Appendices

APPENDIX A

DETAILED TABLES OF RESOURCE PROJECTIONS

Table A-1. Operating costs (budget outlays) in millions of dollars

Program	1977 Actual	1978		1979		ORNL forecasts			
		Budget	ORNL forecast	Budget submission	ORNL forecast	1980	1981	1982	1983
BA Coal	6.9	13.3	13.7	18.8	19.0	24.0	29.0	34.0	39.0
BB Petroleum and Natural Gas	0.6	0.5	0.5	0.8	0.8	0.7	0.6	0.5	0.5
BC In-Situ Technology	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Total Fossil (B)	7.6	14.0	14.4	19.8	20.0	24.9	29.8	34.7	39.7
EA Solar	1.0	1.3	1.8	3.1	2.6	2.8	3.0	3.2	3.4
EB Geothermal	1.0	1.1	1.1	1.2	1.2	1.5	1.5	1.5	1.5
ED Magnetic Fusion	32.9	39.1	32.0	50.7	35.0	38.0	41.0	43.0	44.0
EC High-Energy Physics	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5
EE Basic Energy Sciences	28.8	31.6	31.6	39.8	39.8	39.8[a]	39.8	39.8	39.8
EF Nuclear Physics	5.0	5.4	5.4	6.5	6.5	6.5[a]	6.5	6.5	6.5
Total ASGA (E)	69.1	78.9	72.3	101.8	85.6	89.1	92.3	94.5	95.7
HA Electric Energy Systems	0.6	3.2	3.2	0.7	4.0	4.0	4.0	4.0	4.0
HB Transportation Energy Conservation	0.3	0.3	0.4	0.4	0.5	0.6	0.6	0.6	0.6
HC Energy Storage Systems	0.8	1.7	1.7	2.0	2.0	3.5	3.8	4.0	4.0
HD Buildings and Community Systems	1.9	4.2	5.0	4.9	6.0	7.0	7.0	7.0	7.0
HF Conservation Research and Technology	0.3	0.2	0.2	1.8	0.8	0.9	1.0	1.0	1.0
HG Industrial Energy Conservation	0.5	0.4	0.7	1.3	1.0	1.3	1.6	2.0	2.5
Total Conservation (H)	4.4	10.0	11.2	11.1	14.3	17.3	18.0	18.6	19.1
KG Breeder Reactor	12.2	11.7	12.0	14.2	14.0	16.0	17.0	16.0	16.0
KJ Nuclear Research and Applications	11.2	13.9	16.4	17.7	19.0	20.0	18.0	16.0	16.0
KX Nuclear Fuel Cycle	22.2	24.6	27.5	49.0	35.0	41.0	45.0	45.0	42.0
KZ Special Materials Production	4.2	5.7	6.5	7.9	8.5	6.0	5.0	5.0	5.0
Total Nuclear (K)	49.8	55.9	62.4	88.8	76.5	83.0	85.0	82.0	79.0
RK Environmental Research and Development	18.4	20.1	20.0	24.8	21.0	23.4	24.8	26.4	28.0
RV Life Sciences and Biomedical Applications	7.3	6.7	7.4	8.1	8.0	8.0	8.0	8.0	8.0
RU Decontamination and Decommissioning	0.3	0.4	0.5	0.4	0.8	0.9	1.0	1.1	1.3
Total Biomedical, Environmental, and Safety Research (R)	26.0	27.2	27.9	33.3	29.8	32.3	33.8	35.5	37.3
UB Institutional Relations	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Nuclear Regulatory Commission	17.9	20.4	20.4	22.8	22.8	22.8	22.8	22.8	22.8
Department of Health, Education, and Welfare	4.9	5.8	5.8	6.2	6.2	6.4	6.6	6.8	7.0
Other federal agencies	15.6	13.5	13.5	13.5	13.5	13.7	13.8	13.9	14.1
Total work for others	38.4	39.7	39.7	42.5	42.5	42.9	43.2	43.5	43.9

[a]In the absence of detailed guidance from Headquarters we project a constant level of effort beyond FY 1979.

Table A-2.1. Subcontracting costs, millions of dollars

Program	1977 Actual	1978 Budget	1978 ORNL forecast	1979 Budget submission	1979 ORNL forecast	ORNL forecasts 1980	1981	1982	1983
B Fossil	0.9	1.9	3.9	2.0	5.0	6.3	7.6	8.9	10.3
EA Solar	0.1	0.4	0.6	0.8	0.8	0.8	0.9	1.0	1.1
EB Geothermal	0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
ED Magnetic Fusion	4.4	6.7	7.4	7.4	5.0	5.5	6.0	6.3	6.4
EE Basic Energy Sciences	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
H Conservation	1.2	5.2	6.7	4.6	8.3	10.8	10.9	11.0	11.1
K Nuclear	4.0	8.0	9.8	16.4	10.4	16.4	16.9	16.3	15.7
R Biomedical, Environmental, and Safety Research	0.2	0.2	0.2	0.5	0.5	0.6	0.6	0.6	0.7
Total	10.9	22.6	28.8	31.9	30.2	40.6	43.1	44.3	45.5

Table A-2.2. Major research procurements on operating expenses, millions of dollars

Program	1977 Actual	1978 Budget	1978 ORNL forecast	1979 Budget submission	1979 ORNL forecast	ORNL forecasts 1980	1981	1982	1983
B Fossil	0.6	0.9	0.9	2.1	2.1	2.6	3.2	3.7	4.2
EA Solar	0	0	0	0.2	0.2	0.2	0.2	0.2	0.2
EB Geothermal	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2
ED Magnetic Fusion	4.4	4.3	4.3	7.4	5.0	5.5	6.0	6.3	6.4
EE Basic Energy Sciences	1.0	1.1	1.1	1.3	1.3	1.4	1.5	1.6	1.7
EF Nuclear Physics	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
H Conservation	0.3	0.3	0.3	1.0	0.8	0.8	0.9	1.0	1.1
K Nuclear	5.9	4.5	3.8	9.5	9.5	9.7	9.9	9.6	9.2
R Biomedical, Environmental, and Safety Research	1.1	1.0	1.0	1.3	1.3	1.4	1.4	1.5	1.6
Total	13.6	12.4	11.7	23.1	20.6	22.0	23.5	24.3	24.8

Table A-3. Laboratory forecast for personnel (full-time equivalents)[a]

		1977	1978	1979	1980	1981	1982	1983
B	Fossil	190	220	270	340	400	460	520
EA	Solar	28	37	47	53	56	59	62
EB	Geothermal	30	24	24	31	31	31	31
ED	Magnetic Fusion	375	375	380	380	390	390	400
EC	High-Energy Physics	6	6	6	6	6	6	6
EE	Basic Energy Sciences	774	816	961	961[b]	961	961	961
EF	Nuclear Physics	154	158	176	176[b]	176	176	176
	Total ASGA (E)	1367	1416	1594	1607	1620	1623	1636
H	Conservation	94	97	155	167	181	196	208
KG	Breeder Reactor	288	260	290	330	350	330	330
KJ	Nuclear Research and Applications	237	310	350	380	340	300	300
KX	Nuclear Fuel Cycle	472	515	600	700	700	700	650
KZ	Total Material Production	105	130	190	160	125	125	125
	Total Nuclear (K)	1102	1215	1430	1570	1515	1455	1405
RK	Environmental Research and Development	578	633	640	713	762	808	851
RV	Life Sciences and Biomedical Applications	233	236	238	238	238	238	238
RU	Decontamination and Decommissioning	14	17	28	31	35	38	45
	Total Biomedical, Environmental, and Safety Research (R)	825	886	906	982	1035	1084	1134
UB	Institutional Relations	4	4	4	4	4	4	4
Work for others		1020	1050	1120	1130	1140	1140	1150
Laboratory best estimate		4602	4850	4900	4900	5000	5000	5000

[a]This includes all ORNL staff, full- and part-time, permanent and temporary. In addition, there will be approximately 1170 guest workers and students spending some time at ORNL during 1977. Approximately 200 man-years of engineering effort from UCC-ND Engineering at ORNL and 100 man-years of support services from the Y-12 Plant, as well as 130 man-years of programming effort and 50 other Computer Sciences Division staff, were used at ORNL during FY 1977.

[b]In the absence of detailed guidance from Headquarters we project a constant level of effort beyond FY 1979.

Table A-4. Capital equipment

	1977	1978	1979	1980	1981	1982	1983
Fossil	0	0.3	0.9	3.0	4.0	5.0	6.0
Conservation	0.1	0.1	0.3	1.0	1.0	1.0	1.0
Solar, geothermal, and fusion	4.1	7.2	5.3	5.4	6.4	6.4	6.4
Basic physical sciences	3.0	4.5	7.2	6.5	6.5	6.5	6.5
Environmental and biomedical	1.5	1.8	2.3	3.0	3.0	3.0	3.0
Nuclear energy	6.8	8.7	14.6	14.0	13.0	12.0	11.0
Total programmatic	15.5	22.6	30.6	32.9	33.9	33.9	33.9
General-purpose equipment (through Program EE)	1.7	2.0	3.9[a]	5.0	5.0	6.0	6.0
Total	17.2	24.6	34.5	37.9	38.9	39.9	39.9

[a]Excluding computer equipment. See Chap. 4.

Table A-5. Construction

Program	Description	1977		1978		1979		1980		1981		1982		1983		Total estimated cost
		BA[a]	BO[b]	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	
EE	Conversion of steam plant facility	10.2	1.3	2.0	5.4		4.0		1.5							12.2
EE	Safeguards and security upgrading		1.1		4.4		0.4									5.9
EE	Holifield Heavy Ion Research Facility		12.0		3.7		2.7		0.1							18.5
EE	Improvements to Oak Ridge Electron Linear Accelerator		0.1		0.3											0.4
KZ	New hydrofracture facility		5.4		0.4		3.0		2.0							5.4
KX	Breeder Reactor Program Integrated Equipment Test Facility (IPET)			3.0	2.0	12.4	8.0		5.0		0.5					15.4
EE	Energy Systems Research Laboratory (ESRL)					7.2	5.5	23.0	16.0		7.2		1.5			30.2
EE	Holifield Heavy Ion Research Facility Phase II					2.0	1.3	16.0	3.2	7.0	10.2		8.5		1.8	25.0
EE	Addition to the Oak Ridge Isochronous Cyclotron Building					1.5	0.2		1.1		0.2					1.5
EE	Energy Management System (EMS)					3.0	0.5		2.0		0.5					3.0
EE	Environmental and emergency systems upgrading					6.9	1.0		2.9		3.0					6.9
EE	Modification aimed at compliance with OSHA					3.3	0.7		2.2		0.4					3.3
KX	HTGR Fuel Recycle Hot Engineering Test Facility (HETF)							12.3	4.8	21.6	9.5	3.2	22.9	2.7	2.6	35.8
KX	Advanced Fuel Recycle Program Hot Experimental Facility							15.0	10.0	35.0	30.0		10.0			50.0
KZ	Solid waste handling and decontamination facility							5.0	3.0	20.0	7.0	1.5	8.0	1.5	8.0	29.5
ED	Improvements to fusion energy facilities							7.5	2.0	5.1	4.3		4.0		2.3	12.6
ED	Long pulse experiment							15.0	15.0	5.0	5.0					20.0
KZ	Sludge removal from gunnite tanks							1.5	1.0	2.0	1.5	0.2	1.2	0.2	0.2	4.5
KZ	Off-gas and cell ventilation improvement							2.4	0.4		1.2		0.8			2.4
RK	Toxic substances laboratory and animal facility							3.0	1.0	5.5	2.9	4.0	5.3		3.3	12.5
RK	Energy pollutant control system							2.2	0.5		1.0		0.7			2.2
RK	Toxicology laboratory							1.8	0.4		1.0		0.4			1.8
RK	Addition to aquatic ecology laboratory							1.8	0.2		0.9		0.7			1.8
RK	Information Resource Center for Energy and the Environment							10.0	1.0		5.0		3.8		0.2	10.0

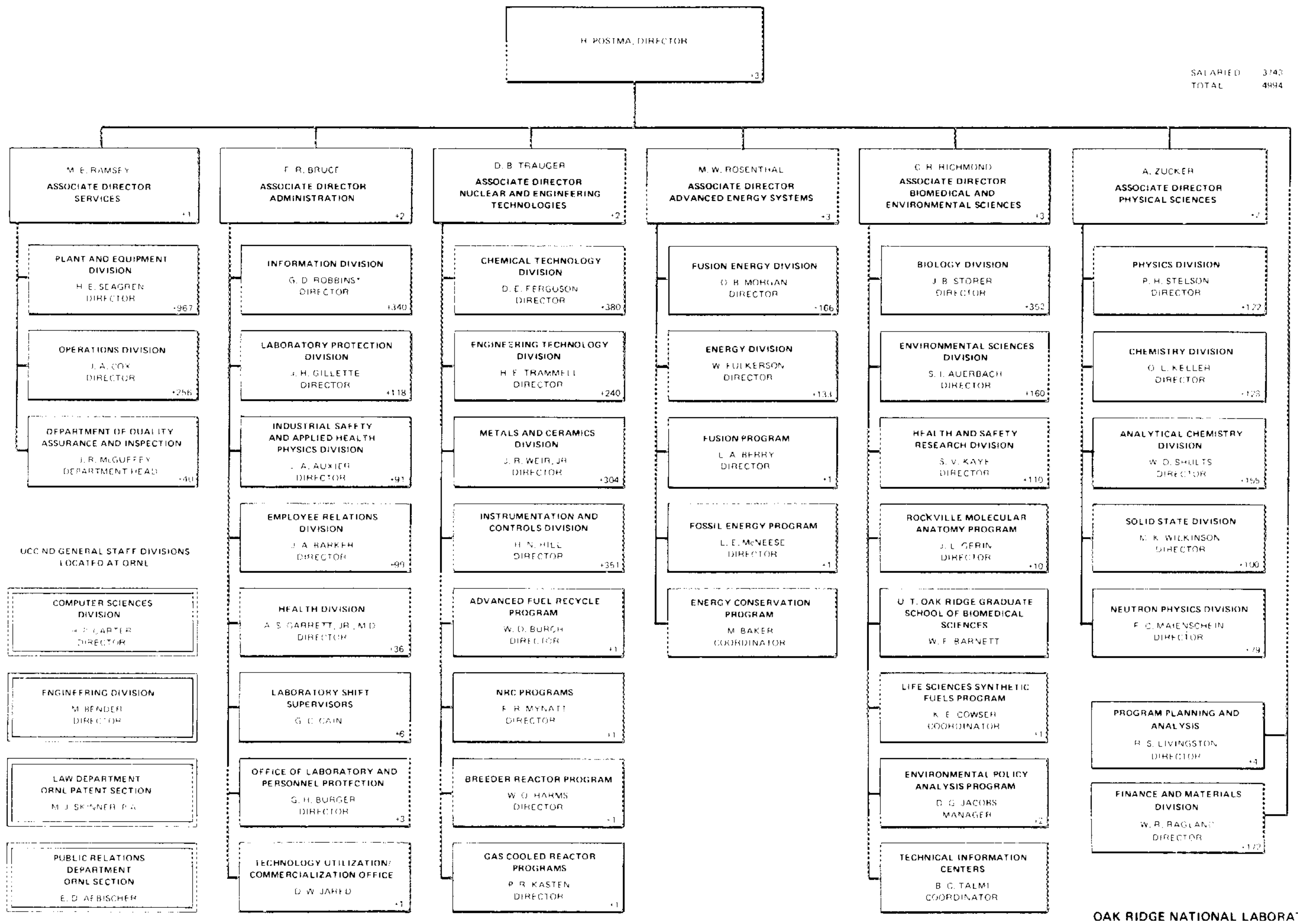
Table A-5 (continued)

Program	Description	1977		1978		1979		1980		1981		1982		1983		Total estimated cost
		BA[a]	BO[b]	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	
EE	Upgrade ORNL primary substation							2.5	0.5		2.0					2.5
EE	Physical security improvements							1.2	0.3		0.7		0.2			1.2
EE	Improvements to fire protection							3.0	0.5		2.0		0.5			3.0
EE	Modifications and addition to stores facilities							3.0	0.3		1.5		1.2			3.0
EE	Emergency control center							2.3	0.6		1.0		0.7			2.3
RK	Upgrade streamflow monitoring stations							1.8	0.6		0.9		0.3			1.8
KZ	Waste operations center							1.5	0.3		0.9		0.3			1.5
EE	High-Temperature Materials Lab (HTML)					4.0	3.8	13.5	9.2		3.6		0.9			17.5
EE	Energy management program								5.0		5.0		5.0		5.0	20.0
	General plant projects through Subprogram KZ	0.5	0.1	0.5	0.4	0.6	0.1									
	General plant projects through Subprogram E	2.8	0.4	2.4	0.4	7.8	1.6									

[a]BA = budget authority.
[b]BO = budget outlays.

APPENDIX B

ORNL ORGANIZATION CHART



**REPORTS TO C. R. RICHMOND FOR INFORMATION CENTER COMPLEX PROGRAMMATIC WORK*

OAK RIDGE NATIONAL LABORATORY ORGANIZATION CHART

CONTRACTOR UNION CARBIDE CORPORATION NUCLEAR DIVISION

CONTRACT NO. W 7405-ENG-26

APPROVED DATE 1/1/78

APPENDIX C

DISTRIBUTION OF ORNL DIVISIONS' BUDGETS AND PERSONNEL ACROSS DOE PROGRAMS

Table C-1. Breakdown of budgets and personnel numbers in ORNL divisions by DOE programs

The top figure represents scientific and technical man-years;
the lower figure in italics represents the budget in millions of dollars.
The date refer to FY 1977

Program	Analytical Chemistry	Biology	Chemical Technology	Chemistry	Computer Sciences	Employee Relations	Energy	Engineering Technology	Environmental Sciences	Fusion Energy	Health and Safety Research	Information	Instrumentation and Controls	Metals and Ceramics	Neutron Physics	Physics	Solid State	Operations	Central Management Offices	UCC-ND ORNL Engineering
B Fossil			29.1 *2.7*	9.5 *0.7*			8.8 *0.8*	14.6 *2.3*						7.1 *0.7*					0.2 *0.3*	2.3 *0.1*
EA Solar							5.9 *0.5*	3.9 *0.3*			1.4 *0.1*									
EB Geothermal				3.2 *0.3*			3.8 *0.3*	1.5 *0.1*						2.9 *0.2*						
ED Magnetic Fusion			1.5 *0.2*							110.5 *30.0*				15.2 *1.4*	2.5 *0.3*	8.4 *0.7*	1.7 *0.2*	– *0.2*		
EC, EE, EF Basic Physical Sciences	11.1 *0.8*		80.1 *5.4*	71.0 *5.6*	– *0.4*									57.6 *4.3*	5.7 *0.6*	72.8 *7.7*	63.5 *5.9*	0.1 *3.3*	0.9 *0.2*	
H Conservation			2.1 *0.3*	2.1 *0.2*			21.8 *2.3*	2.4 *0.8*			3.3 *0.3*			3.4 *0.4*						
K Nuclear Energy Development	4.0 *0.3*		172.1 *16.8*	0.7 *0.1*			0.8 *0.1*	88.1 *8.8*	10.2 *0.9*		3.5 *0.6*	1.3 *0.1*	22.5 *2.2*	126.9 *10.6*	30.9 *3.1*	0.8 –	5.8 *0.3*	20.1 *2.3*	0.8 *1.0*	3.3 *2.4*
R Environmental and Life Sciences	6.0 *0.4*	183.0 *12.6*	17.0 *1.3*	1.0 *0.1*			6.0 *0.6*	2.0 *0.1*	55.0 *3.6*		56.0 *4.3*	12.0 *0.6*	4.0 *0.4*		1.0 *0.1*			11.0 *1.3*	3.0 *0.3*	
UB Institutional Relations						1.8 *0.2*														
Nuclear Regulatory Commission			26.9 *2.0*		– *0.6*		26.4 *2.8*	71.8 *9.3*	3.6 *0.3*		1.7 *0.2*		8.3 *0.8*	11.8 *1.4*	4.2 *0.4*			1.0 *0.1*		
Other federal agencies	21.8 *1.4*	48.7 *3.3*	53.8 *5.0*	1.7 *0.2*	– *0.7*		15.0 *1.1*	3.7 *0.6*	22.3 *2.1*		5.0 *0.3*	42.8 *2.1*	1.1 0.5	4.0 0.3	9.5 *1.1*	0.2 *0.1*	0.2 –		– *1.2*	– *0.2*
Total, man-years	42.9	231.7	382.6	89.2	–	1.8	88.5	188.0	91.1	110.5	70.9	56.1	35.9	228.9	53.8	82.2	71.2	32.2	4.9	5.6
Total, millions of dollars	*2.9*	*15.9*	*33.7*	*7.2*	*1.7*	*0.2*	*8.8*	*22.3*	*6.9*	*30.0*	*5.8*	*2.8*	*3.9*	*19.3*	*5.6*	*8.5*	*6.4*	*7.2*	*3.0*	*2.7*

APPENDIX D

TABLES OF BUDGET OUTLAY ESTIMATES BY PHASE OF RESEARCH, DEVELOPMENT, AND DEMONSTRATION

Table D-1.1. Functional phase of research and development for FY 1977

Laboratory estimate of operating cost (budget outlays), millions of dollars

Program	Basic research	Applied research	Technology development	Engineering development	Demonstration
Energy research, development, and demonstration					
B Fossil		1	6	1	
EA Solar			1		
EB Geothermal		1	0.3		
ED Magnetic Fusion		9	24		
EE Basic Energy Sciences	16	13			
H Conservation		1	3	0.4	
K Fission Energy		11	32	4	4
RK Biomedical, Environmental, and Safety	1	17			
Subtotal	17	53	66	6	4.5
Other research, development, and demonstration (nonenergy)					
EC High-Energy Physics	0.4				
EF Nuclear Physics	4.8	0.2			
RV Life Sciences	7.3				
Subtotal	12.5	0.2			

Table D-1.2. Functional phase of research and development for FY 1978

Laboratory forecast of operating cost (budget outlays), millions of dollars

Program	Basic research	Applied research	Technology development	Engineering development	Demonstration
Energy research, development, and demonstration					
B Fossil		2	11	1	
EA Solar			2		
EB Geothermal		1	0.4		
ED Magnetic Fusion		9	23		
EE Basic Energy Sciences	17	14			
H Conservation		3	8	1	
K Fission Energy		14	37	6	6
RK Biomedical, Environmental, and Safety	1	19			
Subtotal	18	61	81	8	6
Other research, development, and demonstration (nonenergy)					
EC High-Energy Physics	0.4				
EF Nuclear Physics	5.1	0.3			
RV Life Sciences	7.4				
Subtotal	12.9	0.3			

Table D-1.3. Functional phase of research and development in FY 1979

Laboratory forecast of operating cost (budget outlays), millions of dollars

	Program	Basic research	Applied research	Technology development	Engineering development	Demonstration
	Energy research, development, and demonstration					
B	Fossil		2	16	2	
EA	Solar			3		
EB	Geothermal			1	0.4	
ED	Magnetic Fusion			9	26	
EE	Basic Energy Sciences	22	18			
H	Conservation		3	10	1	
K	Fission Energy		17	46	7	7
RK	Biomedical, Environmental, and Safety	1	20			
	Subtotal	23	60	85	36	7
	Other research, development, and demonstration (nonenergy)					
EC	High Energy Physics	0.5				
EF	Nuclear Physics	6.2	0.3			
RV	Life Sciences	8.0				
	Subtotal	14.7	0.3			

Table D-2. Summary of functional phase of research and development

Millions of dollars

Phase	1977 Laboratory estimate	1978 Laboratory forecast	1979 Laboratory forecast
Energy research, development, and demonstration			
Basic research	17	18	23
Applied research	53	61	60
Technology development	66	81	85
Engineering development	6	8	36
Demonstration	4	6	7
Subtotal	146	174	211
Other research, development, and demonstration (nonenergy)			
Basic research	12.5	12.9	14.7
Applied research	0.2	0.3	0.3
Subtotal	12.7	13.2	15.0

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