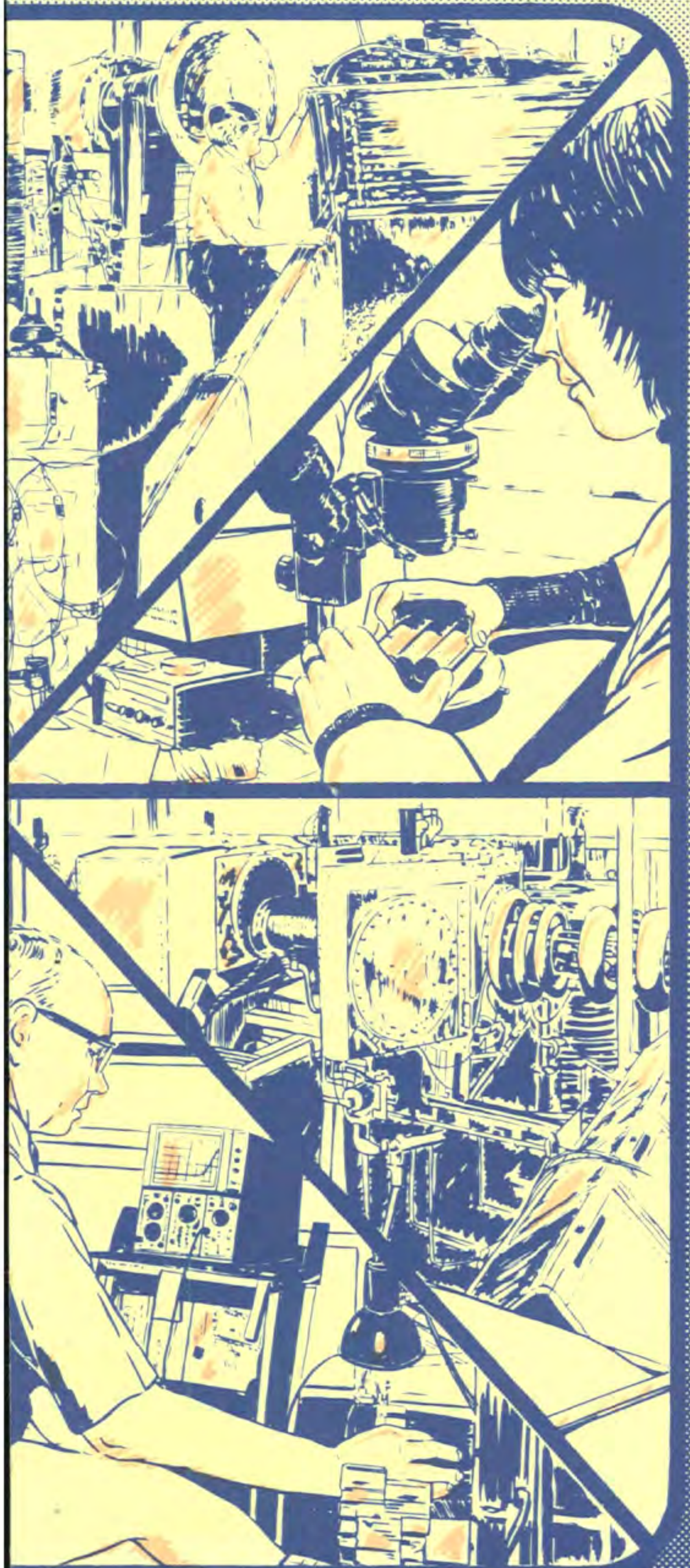

Overview of the LONG-RANGE PROGRAM PLAN 1977–1983 for OAK RIDGE NATIONAL LABORATORY

ENERGY RESEARCH & DEVELOPMENT ADMINISTRATION USA

May 1977

Oak Ridge National Laboratory
Oak Ridge, Tennessee 37830
operated by
Union Carbide Corporation
for the
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Additional copies of the *Overview of the Long-Range Program 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).

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Senior Planning Group
H. Postma
F. L. Culler
C. R. Richmond
M. W. Rosenthal
D. B. Trauger
A. Zucker

Planning Group Staff
J. B. McGrory
C. C. Burwell
D. J. Crouse
J. E. Jones Jr.
R. S. Livingston
J. Poston

Managing Editor
J. S. Nunley

Graphic Design
A. D. Richardson

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EXECUTIVE SUMMARY

Oak Ridge National Laboratory (ORNL) is a *national energy laboratory* concerned with the development and efficient use of environmentally acceptable supplies of energy from various sources. ORNL is a federal government facility controlled by the Energy Research and Development Administration (ERDA), and most of the work carried out at the Laboratory is sponsored by ERDA. The details of the entire program are presented in the main body of the *Long-Range Program Plan 1977-1983* and are highlighted here.

PROGRAM HIGHLIGHTS

The present ORNL program is dominated by four general areas of research and development. These programs, ordered according to the size of their FY 1976 ERDA budgets, are:

- Nuclear Energy Development—fuel cycle [primarily for liquid metal fast breeder reactor (LMFBR) and gas-cooled reactors], high-temperature materials, reactor physics, and reactor safety
- Basic Energy Sciences—properties of materials at high temperatures, radiation damage, heavy-ion physics, neutronics, catalysis, high-temperature chemistry, actinide chemistry
- Magnetic Fusion Energy—physics of toroidally confined plasmas, plasma heating by neutral-beam injection, large superconducting magnet development, fusion reactor technology
- Biomedical and Environmental Sciences—environmental impact of energy effluents, somatic and genetic effects of energy effluents, environmental policy analysis, detection of environmentally associated health effects

The Plan projects program budgets through FY 1983. Between FY 1977 and FY 1983, the Plan projects particularly significant growth in the magnetic fusion and fossil energy programs. Thus, by FY 1983, the ordered list would become:

- Nuclear Energy Development
- Magnetic Fusion Energy
- Fossil Energy—high-efficiency alkali-metal steam systems, fluidized-bed combustion, components testing, basic research in coal chemistry, and properties of materials at high temperatures
- Basic Energy Sciences
- Biomedical and Environmental Sciences

Each of these dominant research areas encompasses a large number of diverse research and development programs. There are one or more programs in each research area which will play especially important roles at ORNL over the next several years. They are important because of the primary position they play in ERDA's program to meet the nation's energy needs and, in most cases, because of the impact they have on total Laboratory resources, by virtue of their size.

Most of these dominant programs integrate a broad range of disciplinary activities. The range of these important programs is described here.

LMFBR Fuel Cycle—ORNL has been assigned the lead role in developing the fuel reprocessing technology of the LMFBR cycle. The central element in this program is the Integrated Prototype Equipment Test Facility, which will be designed and assembled by FY 1981. This facility will provide for testing of the components of an LMFBR fuel reprocessing plant and developing efficient remote maintenance procedures. It is conceived as the precursor to a pilot reprocessing plant, the Hot Pilot Plant, to be built by 1986 to 1988. Basic research in the areas of actinide chemistry and fission-product separation science supports the fuel cycle work. In biomedical and environmental science, the route of radioactive wastes through the ecosystem and the biological effects of radioactive effluents on animals are major areas of investigation in support of the total fuel cycle program. Finally, ORNL will help prepare guidelines for permissible releases of radioactive materials and develop adequate safeguards for the storage of special nuclear materials.

Fusion Power Development—ORNL is a major center of research and development for fusion energy technology. The program concentrates on theoretical and experimental studies of toroidal confinement fusion devices and, in particular, on the use of neutral-beam injection for plasma heating. In 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 area 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. These studies will utilize several of the accelerators and reactors available at the Laboratory. The fate of fusion technology effluents in the ecosystem and the biological effects of these effluents will be studied with increasing intensity in the biomedical and environmental research programs.

Heavy-Ion Science—The Holifield Heavy Ion Research Facility (HHIRF), when completed in FY 1979, will be the center of ERDA's heavy-ion science program. The energetic heavy-ion beams produced in this facility will be used in basic nuclear physics, in chemistry studies of reactions between complex nuclear systems, and in studies of new isotopes far from stability. The beams will be used in applied research on materials radiation damage and actinide chemistry.

Nuclear Reactor Technology—ORNL has an important role in ERDA's reactor technology programs, mainly in support of LMFBR and gas-cooled reactors. Principal components of the program include development and evaluation of structural alloys and fuels and development of high-temperature structural design methods and joining technology. These are complemented by basic research on alloy properties. Neutronics analyses, cross-section measurements, and shielding studies provide an important technology input for reactor design and safety. The program also includes heat transfer and fluid flow studies and development of advanced instrumentation and control methods for reactor systems.

These programs, which are large programs in terms of budget and personnel, are continuations of established programs. ORNL has started a program in coal conversion and is probing for an appropriate role in the other major technologies, conservation and solar and geothermal energies. These efforts are smaller in terms of money and personnel, but they are in areas of high potential impact; we hope they will play a more significant role in our total effort in the next few years.

Coal Technology Program—The coal technology program includes basic research and engineering. Four major engineering components of the coal technology program are (1) a hydrocarbonization development program, (2) a major coal conversion component test facility, (3) a potassium vapor topping cycle facility, and (4) a fluidized-bed boiler for industrial application or for application in Modular Integrated Utility Systems (MIUS). Increasing basic research in coal chemistry and materials should provide a basis for major improvements in advanced coal conversion processes. The environmental and biological impact of coal technology is a growing area of research in the biomedical and environmental sciences.

Conservation—The most immediate means of achieving some of our national energy goals is through energy conservation. Our conservation activities include development of the Annual Cycle Energy System (ACES), evaluation of end-use conservation in household appliances, analysis of insulation materials for industrial energy conservation, and development of low-temperature thermal storage systems.

Solar and Geothermal Energy—The programmatic involvements of the Laboratory in solar energy are in the areas of development of high-efficiency low-cost heat exchangers for ocean thermal conversion, assessment of appropriate goals for solar energy development, and agricultural applications of solar energy. In physical research, methods of nuclear doping and ion implantation will be used to develop high-efficiency photovoltaic cells which use polycrystalline silicon material, as well as other materials. The geothermal program is primarily in the area of chemical and materials basic research, including brine-induced corrosion and the mechanics of scale formation, power cycle development, and analysis of environmental impacts.

RESOURCES NEEDED

The estimated operating costs needed to meet our goals are summarized in Figure 1 for the major program areas. The estimated size of the full-time regular staff is shown in Figure 2. The information in Figures 1 and 2 is discussed in some detail in Chap. V. The budget reaches $280 million in FY 1983, but this figure should not be correlated directly with personnel growth. A considerable fraction of this money (about $75 million) will be put out on subcontracts to private industry or used for construction of research facilities, as we take on more and more program management tasks. Beyond this, the budgets presented in the body of the complete Plan represent the input of individual staff research groups. The sum of these individual budgets is about $400 million. The $280 million total Laboratory budget shown in Figure 1 is based on two considerations:

1. The best thinking of the senior Laboratory management as to the expected directions of major programs at ORNL in the coming years.
2. The fact that, in past years, the final approved Laboratory budget has been about 77% of the initial budget request submitted two years prior to final authorization.

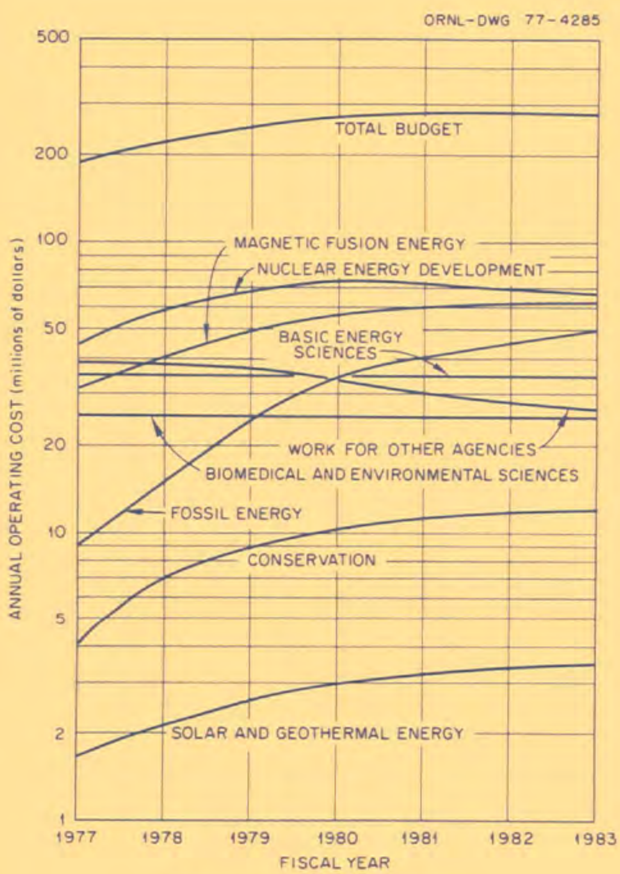

Figure 1. Operating Cost.

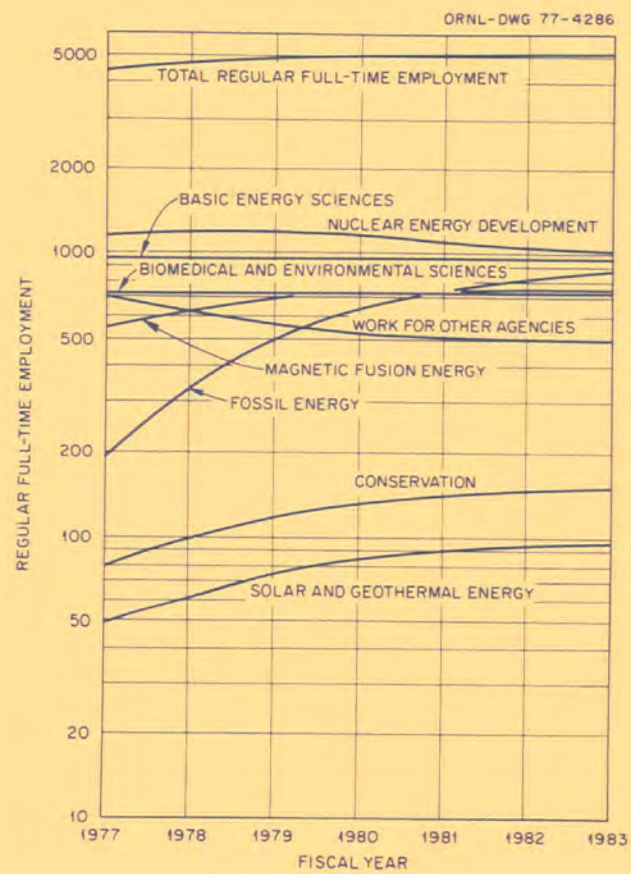

Figure 2. Employment.

KEY ISSUES

A number of problems need to be resolved if our research is to proceed effectively. The issues are stated more fully in Chap. IV of this Overview, but brief descriptors for these key issues are listed here:

Programmatic Issues

- Support of long-range basic research by technology programs
- Long-term national strategy for gas-cooled reactors
- Future role of NRC work at ERDA facilities

Facilities and Research Equipment

- Long-term continuing support of special facilities, reactors, separators
- Adequate computer capacity
- Laboratory and office space for relieving present overcrowded conditions and inadequate buildings
- Funding for general plant projects (GPP) and general-purpose equipment (GPE)
- Adequate review of placement of major new facilities

Administrative Issues

- Transfer of technologies to industry
- Interactive planning between laboratories and headquarters
- Increased program flexibility and breadth
- Creation of "lead laboratories"
- Funding of foreign travel

I. INTRODUCTION

This document is an overview of the Oak Ridge National Laboratory Long-Range Program Plan for the fiscal years 1977 through 1983. It describes what we expect to accomplish during this period, how these accomplishments will be attained, and what resources will be required.

Objectives

The major objectives of the Oak Ridge National Laboratory (ORNL) are:

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

The Laboratory is owned by the federal government, controlled by the Energy Research and Development Administration (ERDA), and supported almost completely by government funds. Thus, it has the responsibility to devote its activities to the major national problems that fall within the areas of concern of the Laboratory's sponsoring agencies. Primary support (80%) is provided by ERDA; about 10% of the work is supported by the Nuclear Regulatory Commission (NRC) and about 10% by other agencies (National Institutes of Health, National Science Foundation, etc.). In addition to conducting research, the Laboratory is a national and regional resource in the education and training of technical personnel and provides some of the best opportunities for professional employment in the Southeast.

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 700 with the Ph.D. degree. There are 700 engineers, primarily chemical, electrical, and mechanical engineers, about 100 mathematicians, 350 chemists, 330 physicists, and more than 300 biomedical and environmental scientists. Finally, there is a growing staff of social scientists, now numbering more than 30. The activities of the Laboratory cover a broad span of related functions: basic research, pilot plant operation, large-scale high-technology development. The ORNL program is dominated by four general program areas that are roughly equal in size, namely, fission energy development, biomedical and environmental research, basic energy sciences, and magnetic fusion energy. In addition, there are rapidly growing programs in fossil energy and conservation.

In support of this program, there exist a variety of special facilities and extensive laboratory and office space. There are a number of unique facilities at ORNL. Included in these facilities are two high-flux reactors now devoted to isotope production, materials irradiation studies, and neutron scattering [High-Flux Isotope Reactor (HFIR) and Oak Ridge Research Reactor (ORR)], and several smaller reactors devoted to shielding and radiation effects studies. There are six charged-particle accelerators engaged in nuclear and atomic physics research, and an electron linear accelerator which is designed to produce neutrons for neutron cross-section measurements. Several laboratories are specifically designed for handling transuranium and other radioactive elements involved in the fission reactor fuel cycle. The world's largest electromagnetic stable isotope separator is at ORNL. In the area of life sciences, there is a 30,000-acre ERDA-owned tract of land ideal for ecological and aquatic studies, and there are extensive animal facilities.

ORNL and two other major ERDA facilities in the Oak Ridge area, the Oak Ridge Gaseous Diffusion Plant (ORGDP) and the Y-12 Plant, are managed under a contract with ERDA by the Union Carbide Corporation Nuclear Division (UCCND). There exists an engineering-support program of 1300 employees plus subcontracted architect-engineers for all three facilities with capabilities far beyond those which would be required for ORNL itself. Also in the Oak Ridge area are the University of Tennessee–ERDA 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 varying periods of time. Finally, ERDA's Oak Ridge Operations Office (ORO) is located in Oak Ridge. ORO will play a particularly important role in the management of technology programs in the future.

Recent Changes in Priorities

The Long-Range Plan must be revised periodically because circumstances change both inside and outside the Laboratory. Since the 1976–1982 Plan was published, a new report *A National Plan for Energy Research, Development, and Demonstration: Creating Energy Choices for the Future, 1976* (ERDA-76), has been published, and the appropriation bill for the FY 1977 ERDA budget has been approved by Congress. We summarize briefly the key changes and trends which are suggested in these documents and which have an impact on the Laboratory's plans.

The ERDA-76 Plan gives an increased priority to the technologies that can make a contribution in the near term (by 1985). In particular, conservation has become the highest priority technology. In addition, ERDA-76 again stresses the importance of the transfer of technology from the laboratories to the stage of commercialization by private industry.

The FY 1977 ERDA budget gives the largest percentage increases (about 100%) to conservation, solar energy research, and research and development related to the nuclear fuel cycle. Other near-term technology programs (fossil fuels, geothermal energy, and solar space heating and cooling) are given about 33% increases. One of the smallest increases (8%) is in the area of supporting basic research.

The FY 1977 budget points to several changes or trends specifically at ORNL. The budget includes no funding for the molten salt reactor project. A decision has been made to place control for the rapidly expanding geologic radioactive waste isolation program in a new Office of Waste Isolation (OWI), which reports directly to the president of UCCND. The budget also indicates that ORNL will have major responsibility for the high-temperature gas-cooled reactor (HTGR) fuel recycle and LMFBR fuel reprocessing programs and will experience a significant expansion in the fusion program. There continues to be a trend at ORNL toward nonnuclear programs in the physical and life sciences, toward environmental sciences as opposed to biological and health sciences, toward large hardware development as opposed to staff expansion, and toward some management responsibility for ERDA programs, accompanied by a decline in work for the NRC and other non-ERDA organizations.

Development of the New Plan

The development of the new Long-Range Plan began with a review of the 1976–1982 Long-Range Program Plan by the technical management of the Laboratory. New program element goal statements and cost estimates were prepared by the staff. The individual program elements were reviewed by the Laboratory Director and Associate Directors, and the sum of these elements was reviewed as a total Laboratory program. Several constraints were put on the total program. We expect the Laboratory to be asked by ERDA to assume responsibility for managing certain programs that will be carried out partly by subcontractors. This is equivalent to saying that the Laboratory will not experience personnel growth proportional to budget growth. We assumed a limit to the growth of the Laboratory staff at an average rate of 2% between 1978 and 1983. A second constraint was imposed by making a deliberate choice of the profile of the Laboratory program we would like to see in the last year considered in the Plan, 1983. We would like to have the percentages of our operating funds shown below under FY 1983 (exclusive of money spent outside ORNL) expended in the indicated areas. For comparison, we show a similar breakdown for FY 1977.

	FY 1977(%)	FY 1983(%)
Basic Energy Sciences	22	19
Biomedical and Environmental Sciences	17	14
Conservation	1	3
Nuclear Energy Development	26	20
Fossil Energy	4	17
Magnetic Fusion Energy	13	15
Solar and Geothermal Energy	1	2
Work for Other Agencies	16	10

This implies relatively strong growth in fossil energy, somewhat less growth in conservation, and some relative reduction in our work for other agencies and in nuclear energy development. The apparent relative decreases in the basic energy sciences and biomedical and environmental sciences results from our assumption that these programs remain at fixed dollar levels in the Plan (see discussion in Chap. V.). One of the most significant changes in the Plan as a result of these considerations is a large increase in the amount of money that will be spent outside the Laboratory by subcontracting and construction.

II. LABORATORY POLICIES

The following policy statements are arranged to deal successively with the questions of who our sponsors will be, what type of work we will undertake, and how we will assure that high-quality work is produced. The Laboratory will:

- Be responsive to the full range of ERDA programs.
- Perform NRC work that utilizes unique local competence and/or augments other existing programs, provides information on which policies and regulations can be based, and avoids conflicts of interest.
- Perform work for other federal agencies and for institutions [such as Electric Power Research Institute (EPRI)] that complements ERDA programs and uses unique Laboratory facilities or skills.
- Seek problems in technology development that are important with respect to national energy needs, use the Laboratory's multidisciplinary capabilities, and 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.
- Use "seed money" funds to encourage the development of innovative programs.
- Cooperate with other ERDA contractors and with universities and local government units, particularly in studies of a regional nature that involve technological questions having political and sociological components.
- Develop joint programs with the Energy Research Centers so that the Laboratory and research centers can make maximum use of each other's expertise.
- Balance Laboratory activities with an appropriate mixture of near-, middle-, and long-term programs.
- Regularly evaluate programs to assure that they contribute to the attainment of Laboratory goals and to establish a basis for decisions when it becomes necessary to redirect program efforts.
- Use assessments and evaluations to guide and support the experimental and developmental programs and to provide information from such studies to policy makers.
- Use social scientists to provide guidance in their areas of competence to the technology development programs.
- Encourage the formation of outside groups to use unique Laboratory facilities.
- Maintain high-quality support organizations and facilities in engineering, computer science, instruments and controls, analytical chemistry, fabrication, maintenance, and health physics.
- Encourage information activities that have a close association with our research and development programs.
- Encourage responsible efforts by the staff to inform the public concerning energy programs.
- Maintain a staff of exceptional quality through highly selective recruiting and careful development.

Of all these policies, the one most important to the success of the Laboratory is the last one. In order better to meet the aim of this policy, the *Long-Range Plan for Human Resources 1976-1981* was developed and published in 1975. The Plan is a statement of Laboratory policy with respect to human resources and a commitment to actions which implement those policies. These commitments are designed to assure the proper availability, optimum utilization, and continuing welfare of a strong and viable staff able to contribute to the achievement of the Laboratory objectives. More than 125 programs are described in the Plan; they deal with staffing, staff development, and the conserving of staff. The staffing programs deal with recruitment, placement, internal mobility, and termination or retirement. The staff development program deals with training and education programs which contribute to employee professional and/or organizational growth. The conserving programs deal broadly with programs that protect and motivate the employees. The *Long-Range Plan for Human Resources* will be periodically reviewed and revised to reflect changing circumstances.

III. LABORATORY PROGRAM SUMMARY

In this section, we present short reviews of the Laboratory programs in the following order:

- Basic Energy Sciences
- Biomedical and Environmental Sciences
- Conservation
- Nuclear Energy Development
- Nuclear Regulatory Commission Programs
- Fossil Energy
- Magnetic Fusion Energy
- Solar and Geothermal Energy
- Information, University Relations, and Commercialization

The programs are organized in much the same way that the programs are organized in *A National Plan for Energy Research, Development, and Demonstration: Creating Energy Choices for the Future, 1976, Vol. 1, The Plan*, ERDA-76. Thus, we first present the broad supporting basic research programs in the physical and life sciences. Then, we discuss the specific technology programs in order of near-, middle-, and long-term technologies. We have combined all our nuclear reactor programs, including breeder reactor efforts, into one section. We discuss work for the NRC separately. Finally, we discuss less-technical support programs.

BASIC ENERGY SCIENCES

To develop new knowledge relevant to the nation's energy goals, an accompanying program of long-range fundamental research must be implemented. Only by gaining new insights can major improvements be made in existing technologies and entirely new concepts developed. A national program of basic energy science must include two types of research. One type looks for new phenomena and/or new fundamental laws and principles. The technological impact of such research is highly uncertain and perhaps remote in time, but it is potentially great and has proved to be the long-range basis for really profound advances in technology in the past. The second type of research is designed to exploit the nearly complete technologies where the basic science is well in hand except in a few critical areas, or where the environmental or health aspects alone preclude widespread utilization. This type of physical research is characterized by its specificity, urgency, and close ties to the national Research, Development, and Demonstration (RD&D) programs. In either case, if optimum application of research results is to occur, there must be a conscious effort to transfer this knowledge to those responsible for development and demonstration. Below, we describe the general areas of research in the physical sciences and highlight the parts of the basic energy sciences program that offer direct support to ERDA's technology programs.

Materials Research

The materials research program is a broad-based program directed at solving materials problems encountered in advanced energy conversion systems. The traditional emphasis in materials science has been on materials for fission reactors. We expect increasing emphasis in the coming years on materials for emerging technologies such as fusion and coal conversion. The mechanical, physical, and optical properties of solids, as well as the characteristics of their surfaces, will be investigated. In the next few years, particular emphasis will be given to physical and mechanical properties of materials at high temperatures in corrosive environments. Materials needed for direct solar energy conversion will be investigated, along with those related to energy transport (e.g., superconductors) and storage. Problems relevant to fusion reactor development, such as atom-surface interactions and diffusion of hydrogen through solids, will be studied. A better understanding of the factors that contribute to the properties of advanced alloys will also be an objective. Basic understanding of the magnetic, electronic, and lattice dynamic properties of solids will be pursued by theoreticians and experimentalists working in close collaboration. Neutron scattering will continue to be a valuable tool in these basic studies. The High-Flux Isotope Reactor (HFIR) will continue to supply neutron beams of unsurpassed intensity for scattering experiments.

Chemical Research

The chemical research program will emphasize the study of catalysis because of the fundamental role it will play in the development of coal conversion, shale utilization, and other chemical energy sources. Thermodynamic and kinetic data relative to conversion processes will be determined, and the analytical chemistry and separation techniques needed for adequate identification and safe handling of noxious by-products will be developed. Thermochemical, photochemical, and biochemical processes for the production of synthetic fuels (such as hydrogen) and electrochemical properties of fused salts needed for the development of high-temperature fuel cells and batteries will be investigated. Hydrates and fused salts for potential use in thermal energy storage systems will also be studied. The corrosive effects and high-temperature chemistry of geothermal solutions will be investigated, as well as the properties and reactions of fusion reactor blanket materials. The electrochemistry underlying stress corrosion will be investigated.

The HFIR will supply important transplutonium elements for research in the United States and foreign countries on the disposal of waste actinides in reactors and the chemical properties of the actinide elements pertinent to prediction of their behavior in the environment.

Nuclear and Atomic Physics and Chemistry

The nuclear and atomic physics and chemistry research program will provide nuclear data, particularly on neutron cross sections, for support of fusion reactor development, for recycling of actinide wastes from fission reactors, for new materials of potential interest for fission reactors, and for materials selected as standards upon which other measurements are based. Nuclear techniques will be applied to the material sciences, and the properties of charged ions in ion-atom and ion-solid interactions will be investigated. Particle-surface interactions and hot-atom chemistry relevant to fusion reactor first-wall problems will be investigated. The microscopic properties of materials to be used in energy conversion devices will be characterized through the determination of the electronic distributions in the materials of interest. In nuclear science, the Laboratory will be a leader in heavy-ion research, a field that is judged to be of increasing interest and importance in nuclear, as well as atomic, physics; results of this research should yield new theoretical insights, as well as new experimental discoveries. The first phase of the new Holifield Heavy Ion Research Facility (HHIRF) will be completed by FY 1979. This laboratory will provide the nation with a source of precise beams of a large variety of heavy ions useful to nuclear physics for nuclides over the entire periodic table and to atomic physics over the full range of elements. In FY 1979, we will request the authorization of phase II of the HHIRF, the addition of a powerful second-stage accelerator to extend the capabilities of the facility and make it the most versatile and most powerful heavy-ion laboratory in the world. Heavy ions allow us to produce neutron-like damage in materials at much faster rates than any neutron source now known; this is of great significance to radiation-damage studies. The new laboratory will also enable researchers to push the limits of known nuclides further into the "sea" of instability and into the region of the superheavy elements, if these prove stable for even very short periods. This facility will be available equally to users from ORNL, universities, and other laboratories.

Engineering Sciences

The engineering sciences research program will provide fundamental chemical and physical information for advanced energy systems and will study the basic engineering aspects of conversion systems such as transport processes, turbulent flow phenomena, and separations processes. New concepts, such as bioreactors and large-scale reversible chemical sorption systems for storage and recovery of energy, will be investigated.

BASIC ENERGY SCIENCE SUPPORT OF TECHNOLOGY PROGRAMS

An appreciable fraction of the effort of the basic energy sciences program is oriented toward direct support of ERDA technologies. In FY 1977, for example, approximately 10% of the basic energy sciences budget will support research directly applicable to the fusion reactor technology program. This research includes (1) studies of methods for the separation and containment of tritium; (2) studies of the effects of radiation on materials relevant to magnetic fusion devices; (3) studies of plasma-surface interactions, including the effects of impurity ions; and (4) the evaluation of neutron cross sections at energies and with materials characteristic of the fusion reactor concept. Another 10% of the basic energy sciences budget supports research bearing directly on problems of fission reactor technology. This research covers neutron cross-section measurement and evaluation, materials studies, separations studies for waste stream processing, and the production, separation, and study of the actinides.

Basic studies pertinent to the fossil energy programs will continue to receive increasing attention. Research into the structure of coal will develop information at the molecular level to assist in the development of economic coal conversion processes. The coal combustion and pyrolysis processes will be studied, along with the structure and properties of both homogeneous and heterogeneous conversion catalysts. The corrosion of structural materials by the harsh environments generated in conversion processes is being investigated.

In solar energy conversion, materials and process problems relevant to solar energy conversion are under study. One program will give special attention to techniques for the preparation of single-crystal and polycrystalline semiconducting materials for improved efficiencies of photovoltaic conversion. A study of the physical properties of selective absorber coatings is planned in the near future. Other areas of investigation include the energy transfer process in photosynthesis and photophysical processes. We hope to initiate a study into solar energy conversion by photosensitive reversible equilibria in the near future.

Basic research relevant to geothermal energy conversion at ORNL is currently directed toward determining the thermodynamic and physical-chemical parameters of geochemical and geophysical processes. We propose to investigate the thermochemical behavior of magmas and the interaction of aqueous media with constituents of natural formations.

In conservation, we now have basic physical research programs in hydrogen production and energy storage, and we hope to begin a program looking at the low-temperature alternating-current transport properties of metals. In energy storage, the possible role of superionic conductors as solid electrolytes in advanced battery systems is being investigated, along with the physical chemistry of high-temperature fuel-cell electrolytes such as molten carbonates.

BIOMEDICAL AND ENVIRONMENTAL SCIENCES

Environmental Research

A unique contribution of ORNL in environmental research derives from its capabilities to attack problems with an integrated ecosystems approach. We have developed a comprehensive program of investigation of basic ecosystem processes and assessment of the impact of effluents from specific energy technologies on the environment. The activities encompass both the coal and nuclear fuel cycles, including low-level waste management. Future research 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. Thus, this effort represents a significant test of our present ecosystem insights and our ability to assess environmental impacts.

Carcinogenesis and Mutagenesis Testing

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 large human populations for a variety of potentially hazardous substances. Development of the testing systems is supported by research efforts in carcinogenesis and mutagenesis required for the validation and improvement of the tests.

Toxicologic Effects Research

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, and determining the dose received. These problems will require development of new procedures and new general knowledge on which to base these procedures. The aim of the research is to predict the hazards to humans from exposure to energy by-products through comparative toxicity studies in experimental animals. Thus, a rational basis for limiting exposures can be provided, and, moreover, the results should assist in the selection of safe technologic processes.

Early Detection of Environmentally Associated Health Effects

The objectives of the early detection program are to provide the maximum possible contribution to national health goals and serve the needs of the biomedical community through various approaches, including the development of innovative radionuclide systems. These objectives will be attained by integration of the Laboratory's capabilities in the areas of (1) research and development of radionuclides, (2) synthesis of radiopharmaceuticals, (3) elucidation of biological mechanisms of pharmacology and distribution in the body, (4) immunology, (5) measurement of radiation dose to body organs from radiopharmaceuticals, (6) development of instrumentation specific for nuclear medicine applications, and (7) development of computing technology for biomedical application. Early detection of possible adverse human health effects associated with fuel cycles for various energy-producing technologies is important because early detection increases the probability of modifying or repairing the effect.

Biotechnology

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 the organic contaminants in the effluents of coal conversion processes by bioreactors utilizing immobilized enzymes or microorganisms, coal beneficiation and resource recovery by slurry reactors using microorganisms, and removal and concentration of dangerous heavy-metal pollutants or resource materials from dilute aqueous streams using bioreactors.

Coal Conversion Technology—Health and Environmental Effects

The coal conversion study will provide the information necessary to ensure that coal conversion will be an acceptable technology when implemented on a large scale. To attain this goal, potentially hazardous constituents in effluent and product streams will have to be identified and characterized, methods of monitoring must be developed. Information on the carcinogenic, mutagenic, teratogenic, and toxic properties of these constituents, as well as on their potential impact on the environment, are needed. Physical and biological information related to environmental transport is also necessary before an assessment of the potential hazards can be made.

Environmental Policy Analysis

ERDA has the responsibility for creating energy choices for the future that are economically sound, socially acceptable, and in accord with health, safety, and continued acceptable environmental quality. Nuclear energy is receiving considerable attention relative to its safety and deleterious effects on health and environmental quality. Environmental policy issues concerning the nuclear fuel cycle and, in particular, nuclear waste isolation are being directed to ERDA for analysis, evaluation, and judgment. The Office of Environmental Policy Analysis has been established recently by ERDA to deal with current and future policies relating to the development and utilization of energy and to provide inputs for decision making by ERDA management and higher councils of government. Each multipurpose ERDA laboratory has established an Office of Environmental Policy Analysis. In this program, ORNL has been assigned responsibility for performing critical issue analyses of the nuclear fuel cycle (particularly the management of radioactive wastes), coal conversion technology, and possibly the general area of toxic substances.

CONSERVATION

Energy conservation is a high-priority program in the overall set of federal energy activities. The program is in recognition of the need for careful custodianship of diminishing U.S. resources of oil and gas, the environmental benefits of reducing energy demand through improving the efficiency of energy use, and the high cost of importing oil and gas, extracting new indigenous oil and gas resources, or converting coal to these fuel forms. The federal conservation program deals with energy policy formulation and technology development at the point of energy end use. This program is divided into six major categories: industry, buildings, transportation, electrical systems, storage, and modeling of energy use. Programs within each category are designed to improve the efficiency of energy end use, to use or recycle waste energy and materials, and to substitute end-use technologies based on plentiful U.S. fuel resources for those dependent on fuels in short supply.

The major continuing conservation activity at the Laboratory focuses on consumptive end uses in buildings. It includes analyses of heating and cooling systems, energy loss through the walls of structures, the efficiency of various appliances, and lighting. Air-conditioning systems, heat pumps, and compressor designs are being studied. A major new activity will be in energy storage, where the Laboratory has been assigned the responsibility for developing the low-temperature element of thermal energy storage by sensible heating and phase-change modes for a wide range of heating and cooling applications. This involves storage applications at temperatures up to about 250° C.

Other activities include studies on insulation materials, particularly high-temperature insulation for industrial process applications and gaseous and liquid insulators for high-voltage electrical transmission. The Laboratory is involved in the development and use of computer models and data bases to assist in evaluating energy conservation policies, technologies, and strategies. In addition, conservation-related activities at the Laboratory include the development of coal-fired Modular Integrated Utility Systems (MIUS) and an alkali metal vapor topping cycle for power plants.

NUCLEAR ENERGY DEVELOPMENT

In the fission energy area, the Laboratory concentrates strongly on the nuclear fuel cycle in its entirety, on special aspects of reactor technology, and on nuclear safety.

Nuclear Fuel Cycle

All facets of the nuclear fuel cycle must be well established technologically and economically if nuclear power is to be acceptable and safe. The Laboratory will be increasingly involved in developments bearing on fuel fabrication, fuel reprocessing and refabrication, and waste management. The Laboratory is concerned with fuel cycle developments for the LMFBR and the HTGR and is participating (with the Savannah River Laboratory) in the new ERDA effort to establish a viable light-water reactor (LWR) fuel reprocessing industry.

The LMFBR fuel reprocessing program focuses on development of processes and equipment for the steps where this technology departs from present reprocessing methods. This includes development of methods for retention of krypton, tritium, and carbon-14 and much more efficient methods for retention of iodine in the processing plant. Particular attention is also being given to development of equipment and techniques for remote operation and maintenance. Much of the new technology is potentially applicable to LWR fuel reprocessing. The effort in this program is being rapidly expanded; the objective is to achieve operation of a hot reprocessing pilot plant for LMFBR fuel by 1986 to 1988. A second major element in the LMFBR fuel cycle is the development of high-performance fuel elements with both advanced fuel and cladding materials capable of attaining high burnup, which is essential for short doubling time.

The Laboratory has been delegated overall management responsibility for the HTGR fuel recycle program, including conceptual design of an HTGR fuel recycle demonstration facility (HRDF). Under this program, the Laboratory is responsible for fuel refabrication development, for hot-cell testing of key processes and equipment for both fuel reprocessing and refabrication, and for coordinating activities in this area with the General Atomic Company, Allied Chemical Corporation, and others.

High-Level Wastes

The final step in the fuel cycle, the management of the high-level wastes, is a major public issue and potential obstacle to nuclear power development. New approaches to waste management, including partitioning of the long-lived actinides from the shorter-lived fission products, are being evaluated for potential inclusion in the overall waste management system.

Reactor Technology

The ORNL reactor technology efforts are concentrated in areas where ORNL has unique capabilities, particularly in reactor physics and materials studies. The principal emphasis is in support of the LMFBR, but important support is given to gas-cooled reactor programs, and the benefits from these programs cross several reactor systems. With respect to LMFBR support, the Laboratory has an important relationship with the Clinch River Breeder Reactor Plant (CRBRP) project; our research results will be applied to the design, operating philosophy, and licensing considerations for the CRBRP.

Oak Ridge National Laboratory has the only reactor in the United States, the Tower Shielding Facility (TSF), that is designed for shielding studies. Computer codes are developed for reactor shielding design calculations and are verified through experiments at the TSF. Related radiation transport methods are developed for calculations of the cores of LMFBRs and gas-cooled fast reactors (GCFRs). A program of neutron cross-section measurements is carried out at the Oak Ridge Electron Linear Accelerator (ORELA), the most advanced facility of its type.

The materials program is mainly directed toward development of a verified high-temperature structural design and materials technology applicable to reactor vessels, components, and core structures. The materials development work aims at understanding materials behavior in regions of temperature and stress beyond the elastic limits and eventually will result in new materials and engineering standards for LMFBR and other high-temperature systems. There is a growing program on development of advanced alloys and fuels for use in LMFBR cores. Materials efforts in support of gas-cooled reactors include fuels and materials development, fission product behavior and coolant chemistry studies, and behavior of prestressed concrete reactor vessels.

The Laboratory has important involvement in development of reactor surveillance and diagnostics measurement methods and instrumentation.

In the blowdown heat transfer (BDHT) program, heat transfer data are being obtained in an electrically heated simulated core under LWR core conditions that would exist immediately following accidental blowdown and during activation of the emergency core cooling system (ECCS). This information is needed to confirm adequacy of the present ECCS. Important materials studies are also being made to determine the amount of swelling and oxidation of Zircaloy fuel rods that would result from the temperature-pressure transient during and after blowdown.

The LMFBR safety program centers on determining the thermal-hydraulic behavior of LMFBR fuel assemblies under normal and accident conditions (flow loss, coolant channel blockages, etc.) and on investigating the release of radionuclides from fuel under a range of accident conditions. There is a rapidly growing program on LMFBR safety analysis.

NUCLEAR REGULATORY COMMISSION PROGRAMS

The legislative act creating the Nuclear Regulatory Commission (NRC) specifies that, where possible, ERDA shall make its facilities available to NRC. Approximately 10% of the total Laboratory budget comes from NRC. The Laboratory conducts programs for NRC in both nuclear safety research and nuclear regulation.

Reactor Safety Research

All the LWR safety studies at ORNL and important parts of the LMFBR and HTGR safety studies are funded by the NRC. The NRC safety programs are discussed in the previous section on reactor safety.

Nuclear Regulation

The Laboratory is involved in the regulatory program in several important areas, including preparation of environmental statements for nuclear and related systems, assistance in safety reviews for the licensing of fuel reprocessing plants, the preparation of "as low as reasonably achievable" (ALARA) guides and assessment methodologies for the release of radioactive materials, and safeguards development. For the first of these activities— preparation of environmental statements—we are concentrating on areas where our interdisciplinary capabilities can be brought to bear on nonroutine assessments, including the development of unified transport modeling techniques and the social aspects of plant siting. Efforts in the safeguarding area concentrate on materials handling during the nuclear fuel cycle. This includes development of computer-based theft detection systems. Pilot plants developed for these systems will serve as safeguards models for commercial nuclear power plants.

Other Research

Several research programs are being carried out for NRC in areas other than reactor safety. These programs are intended to enhance the NRC's ability to perform the assessments and reviews that are a necessary part of the licensing process. These programs include research in social impacts, environmental effects, waste management, and computer modeling and forecasting.

FOSSIL ENERGY

The United States currently imports about one-half of its oil requirements. Future demand for oil and gas will continue to outstrip the domestic supply to an increasing degree. The major goals of federal activities in fossil energy are to (1) augment domestic supplies of oil and gas through enhanced recovery of conventional resources and through development of a process technology to allow use of oil shale resources and (2) increase reliance on the plentiful supplies of coal through development of technology to allow direct combustion in an environmentally acceptable fashion and through development of process technology to convert coal into liquid and gaseous fuels.

The major effort of the ORNL fossil energy program is on coal utilization, both by direct combustion and by conversion. A small program of supporting research contributes to enhanced oil recovery.

The Laboratory's program on direct combustion is oriented toward development of fluidized-bed coal combustion systems. A companion program is the development of an alkali metal vapor cycle for converting high-temperature energy to electricity with an overall thermal efficiency approaching 50%.

Coal-fired fluidized-bed systems utilizing a small closed-cycle turbine obtaining energy from the fluidized bed are being developed. The systems are potentially applicable to MIUSs serving residential and commercial customers, or they can be scaled up to industrial size. These systems will generate electricity, and process or space heat will be recovered from the exhaust gas.

The Laboratory's program on coal conversion includes a laboratory development program on catalysts, solid-liquid separation, coal analysis, and chemical structure of coal. This effort is substantially enhanced by fundamental work in the Laboratory's basic energy sciences program. Engineering development work on coal conversion is directed toward both process and component development (particularly for liquefaction).

Supporting both the direct combustion and coal conversion activities are expanding programs in engineering studies and evaluations and in materials engineering. The Laboratory's studies and evaluations programs will be used to evaluate alternatives, identify R&D requirements, and contribute to the planning process for fossil energy development. The Laboratory will have a lead role in environmental assessments and information dissemination involving coal conversion and utilization.

Finally, a major new activity in components testing is being proposed at the Laboratory. The initial element of this program would be a valve test module and would be the first unit of a Critical Components Test Facility for valves, pumps, compressors, turbines, coal preparation equipment and feed systems, pressure vessels, and gas cleanup equipment.

MAGNETIC FUSION ENERGY

Two basic approaches to controlling the nuclear fusion process are being pursued in the federal RD&D program: (1) magnetic fusion—magnetic confinement of atomic ion plasmas to simultaneously attain the required plasma densities, temperatures, and confinement time; and (2) laser fusion—inertial confinement systems based on use of high-power laser and electron beams to initiate the burning of small packets of thermonuclear fuels solidified through the use of cryogenic temperatures.

The federal program in support of magnetic fusion is organized into four subprograms: confinement systems (conduct of major experiments), development and technology (engineering support for experiments and reactor design), applied plasma physics (theoretical and computational activities), and reactor projects (construction of large projects). The Laboratory has key roles in all these magnetic fusion subprograms.

Oak Ridge National Laboratory's effort on plasma physics and confinement systems is aimed at making significant contributions to the U.S. and international undertaking to bring toroidal systems to the point that they can be used for practical power plants. Our present activities center around the operation of ORMAK and the Elmo Bumpy Torus (EBT). During the immediate future, we expect to construct two toroidal magnetic confinement devices. The first, a relatively inexpensive tokamak device about the size of ORMAK but with greater experimental capability, will be built in cooperation with the General Atomic Company and will be used to investigate impurity effects and to develop diagnostic capability. The second, also a tokamak, will replace the present ORMAK device with a slightly larger, high-field device that will explore the limits of neutral injection heating and plasma pressure.

Operation of the EBT will continue for several years; a decision about whether or how to further exploit the bumpy-torus concept will be made in the near future.

The general goal of the fusion reactor technology and development programs is to provide the components and systems that will be required for producing stable thermonuclear plasmas and for extracting power in practical, economic systems. Our major responsibilities are the development of the large superconducting magnets that will be needed for tokamak power reactors and the development of the high-power, high-energy neutral-beam injectors that are needed for the experimental toroidal devices now being built and for future power-producing systems. Investigation of the behavior of materials represents a smaller activity at present but will expand into a larger program aimed at identifying or developing materials usable under reactor conditions. Our present small investigation of tritium behavior is expected to grow into a program to develop the systems needed for the handling and containment of tritium in power reactors. A program in fusion reactor fueling technology has been initiated and is expected to grow substantially in the next few years.

Finally, we are performing the conceptual design of The Next Step (TNS), the first experiment in the U.S. program that would be capable of igniting a deuterium-tritium plasma. Plasma system design and timing will depend on what is learned in the magnetic fusion effort during the next several years, but we propose that ORNL be given an early assignment of responsibility for construction and operation of TNS so that an orderly design and development program can begin soon.

TNS will have a superconducting magnet system and will be as large as or larger than the deuterium-tritium burner with conventional copper coils now being built at Princeton. It will provide a testing system for demonstration of superconducting coils and large neutral-beam injectors. It will also contribute to the understanding and resolution of important physics questions having to do with the control of large plasma currents, large heating power inputs, and the physics of fusion-like plasmas.

SOLAR AND GEOTHERMAL ENERGY

Solar energy and geothermal energy are large energy sources that are essentially unused for energy production today because of technical and/or economic considerations. The collection, transformation, and use of solar and geothermal energy are different from traditional approaches to conversion of stored fuel such as coal or oil for energy production.

Solar

The federal RD&D program for solar energy is divided into activities leading to near-term use of solar energy for heating and cooling buildings and activities leading to long-term development of the solar-electric technologies: solar thermal, ocean thermal, photovoltaic, wind, and biomass.

The Laboratory's present small effort in solar energy is directed toward the long-term technologies, including thermal conversion, photovoltaic conversion, and assessment of economic and environmental impacts.

In thermal conversion, the major effort is in developing high-performance–low-cost heat transfer technology applicable to ocean thermal energy conversion. Another program incorporates studies of the application of the Laboratory's considerable expertise in high-temperature molten salt technology to the solar "power tower" concept. Finally, the Laboratory is providing technical support to ERDA through studies and evaluations of solar electric applications and alternatives.

Photovoltaic conversion devices are currently not economically feasible except for special applications. The Laboratory's materials research capabilities will be applied to preparing high-purity polycrystalline silicon material, rendering the material into sheets of solar-cell quality, and controlling properties through nuclear doping, ion implantation, and other techniques in an effort to improve efficiency and reduce cost of solar cells.

A key element in many applications of solar energy is storage. The Laboratory plans to participate in the study and evaluation of solar energy in agricultural, industrial, and biophysical applications where production and use of various forms of biomass provide inherent solar energy storage.

Geothermal

The federal RD&D program in geothermal energy conversion incorporates all major sources of geothermal energy: vapor-dominated hydrothermal, liquid-dominated hydrothermal, and hot dry rock. The Laboratory's efforts are concentrated on (1) low-temperature power systems, (2) scale formation, (3) corrosion, and (4) environmental assessments. Low-temperature power systems activities include development and testing of improved heat transfer technology, better methods of collecting heat, and conversion to useful work in Rankine-type engines. Studies and field tests will be performed in control of corrosion and scale formation. In the area of environmental assessment, the Laboratory will take a lead role in analysis of ERDA geothermal programs.

INFORMATION, UNIVERSITY RELATIONS, AND COMMERCIALIZATION

Information

The explosion of technical information has created a need for information centers featuring computer processing, storage, and rapid retrieval of selected bibliographic information. All scientific information, including computer technology and compilations of numeric data, requires technical evaluation and repackaging into more useful exchangeable forms. A large number of specialized information centers have grown at the Laboratory in response to programmatic needs. The centers in the biomedical and environmental fields have been organized into a single complex, which we expect to grow rapidly during this planning period. The established information analysis centers, embedded in the programmatic divisions, can expect a steady increase in usage during the period.

University Relations

Because of ERDA's interest in personnel development, we will continue and expand our cooperative programs with universities. New emphasis will be given to involving social science students and faculty in our programs and to increasing the opportunities for minority students in the engineering disciplines. The University of Tennessee Oak Ridge Graduate School of Biomedical Science will continue to be an important center for graduate education in the biomedical sciences and will add programs in environmental sciences. The first E. P. Wigner postdoctoral appointments were made in 1976. The number of appointments will be increased from five to ten in 1977.

Commercialization and Technology Transfer

ERDA has as a high-priority objective the rapid transfer of energy technology from the laboratory to private industry for commercial development. The technology utilization program, which includes the publication of the Industrial Cooperation Bulletin, will continue to bring research spin-off ideas to the attention of private industry. Many large high-technology capital-intensive energy development programs will be carried forward in collaboration with private industry. A pilot program for the development of an energy extension service will be started in cooperation with the University of Tennessee. It will aim to transfer conservation and solar "small" technology to private citizens and to small business and industry.

SOCIAL SCIENCES

The role of the social sciences in the national energy technology development program is expected to grow at an increasing rate in the next few years. We briefly discuss the Laboratory's overall social sciences program here. Specific activities are described in the technological program elements discussed below.

The involvement of the Laboratory in the development of information related to the social issues of energy production and use continues to grow. In April 1976, the Laboratory employed 32 social scientists. Nineteen of these were full-time employees, of whom 13 held Ph.D. degrees. Half the social scientists were economists. Other disciplines represented included sociology, political science, and geography. The social science programs are integrated closely with the technology research programs, primarily with the activities of the Energy Division. Social science research in regional analysis focuses on four areas: (1) the prediction of economic activity and the associated supply and demand of various energy sources for a given geographical region, (2) development of computer-assisted methodology to assist in site selection for various energy facilities, (3) analysis of socioeconomic effects, and (4) collection, organization, computerization, and analysis of tabular geographical data.

In addition, social scientists are (or will be) involved in the development and application of engineering-economic models of residential, commercial, and industrial energy use and are participating in the preparation of environmental statements.

As was mentioned in the program element on university relations, the Laboratory is seeking to increase the involvement of undergraduate students in the social sciences in various training programs.

IV. KEY ISSUES

The Laboratory faces some difficult technical problems in helping to accomplish national goals. Given adequate funding and sufficient time, most of these problems can be overcome. However, certain issues related to ERDA policies and concepts concerning resource allocations will have a strong influence on the Laboratory's success in solving these problems. Some of these are listed below.

PROGRAM ISSUES

Programmatic Support of Basic Research

The ultimate success of technology development programs, particularly for the middle- and long-term technologies, will require the development of a broad base of fundamental knowledge achieved through a strong basic research program in the physical and life sciences. In FY 1977, approximately $11.0 million of Division of Physical Research (DPR) funds will be spent on basic research directly supporting various energy technologies. This support will double for FY 1978. The basic research needs must be recognized within the various technology programs, and an increased share of programmatic funds should be directed to the support of basic research.

Funding of Gas-Cooled Reactor Projects

In the past year, private industry has acted to reduce its involvement in the HTGR development program. There is now great uncertainty as to the future of this program, a large component of which is at ORNL. If the HTGR program were terminated, many of the people could be absorbed in some of the fuel cycle programs. Thus the uncertainty in the HTGR program introduces an uncertainty into the remainder of the reactor program. The HTGR development is important as a precursor to the GCFR, the most promising alternative to the LMFBR. The present low funding of the GCFR is inconsistent with the commitment to develop a breeder reactor as part of the long-range solution to the energy problem.

Nuclear Regulatory Commission (NRC) Work at ORNL

At present, NRC work comprises 10% of the ORNL research effort. In the next few years, we expect ERDA support at ORNL will increase at a faster rate than will space and/or staff. In the projections shown in the Plan, the total Work for Others (WFO) program decreases by 30% between FY 1977 and FY 1983. This will mean that the Laboratory will be unable to accept some requests from the NRC. On the other hand, NRC requests of national laboratories could decline as a result of efforts to divorce nuclear regulatory activities from nuclear energy development activities. ERDA and NRC should reach agreement on the involvement of ERDA laboratories in NRC work and the level of NRC work at national laboratories.

FACILITIES ISSUES

Support of Special Facilities

Several of the large facilities at the Laboratory (e.g., reactors, accelerators, isotope separators and processing plants, animal facilities) are service facilities for the nation. In large part, they are funded by service fees. When the users are few and in diverse programs, a decision at a low level of management to cut back on the use of the facility results in higher prices to other users. An obvious chain of events can lead to shutdown and the loss of a valuable facility because of a few decisions made at a relatively low administrative level. The Oak Ridge Research Reactor (ORR) is a specific case in point. Uncertainties in the use of the facility by the HTGR project for fuel element studies or by the Magnetic Fusion Energy (MFE) program for radiation damage studies and the possibility that NRC will put some of its work overseas all threaten the continued operation of this valuable research tool. A similar situation is developing with respect to the High Flux Isotope Reactor (HFIR). ERDA should give its full support and assistance to the continued operation of these valuable national assets.

Computer Needs

A report, *Computing Facilities Long-Range Plan—Oak Ridge National Laboratory 1976-1982,* was issued in March 1976. This report indicates that in order to meet the demands for batch processing of computer input at ORNL in 1977 and 1978, a computer in the class of the IBM 370/195 must be acquired in FY 1977 and a next-generation interactive computer must be added in FY 1979. The request for the first computer has already been deferred until FY 1979. If prompt action is not taken by ERDA to authorize these computers, ORNL will face a serious computer saturation problem in early FY 1978.

Laboratory and Office Space

ORNL is thirty-five years old. Many of the original buildings, still in use, are deteriorating. In the past few years, the Laboratory staff has grown and new programs have started. These new programs create unique requirements which are not met by our present buildings. A proposal has been made for an Energy Systems Research Laboratory (ESRL) to meet some of these needs in the new nonnuclear energy technology programs. The fusion program has undergone a large expansion; there is a need to restructure the present facilities at Y-12 for the fusion program to provide adequate space for this expansion. Prompt action on these proposals is needed to ensure that space limitations will not impede the progress of these programs.

Funding for General Plant Projects and General-Purpose Equipment

Our General Plant Projects (GPP) and General-Purpose Equipment (GPE) budgets have been inadequate for several years. Antiquated facilities must be replaced, and existing research and service facilities must be modernized. Some of these modifications are required to meet fire codes. GPP funding is needed to purchase modular office units to help solve our space problem. The inadequate funding for GPE has not allowed ORNL to comply with equipment replacement criteria established by ERDA. Designated GPP and GPE funds should be provided to realize significant energy savings in our plant operation through the installation of a centralized computerized energy control system. GPP funding in past years has been between \$2 and \$3 million per year. We estimate that ORNL could meet these needs if this level were increased to \$5 million per year. Similarly, GPE funding in recent years has been about \$1.5 million. This level should be doubled and then allowed to grow with the size of our operating budget.

Placement of Major Facilities

ERDA's present procedures for selecting sites for new major facilities implicitly require many installations to prepare and submit proposals for many different facilities. The preparation of these proposals is expensive and consumes much of the time of outstanding people. The procedures should be modified so as to reduce these inefficiencies.

ADMINISTRATIVE ISSUES

Transfer of Technologies to Industry

ERDA has wisely placed a high priority on the rapid transfer of new technologies to industry. Development programs and administrative policies should be structured to encourage active cooperation between the national laboratories and industry. We hope that the implementation of patent policy under ERDA will not inhibit this cooperation. Internally, we need to develop more effective policies to encourage cooperative projects with industry, including temporary transfer of personnel. Planning for technology transfer activities should begin early in the stages of RD&D activities that lend themselves to eventual transfer, and mechanisms to ensure the accuracy and soundness of such planning should be set up.

Planning

Development of ERDA plans in research and development should be an interactive process between ERDA program managers and the managers at ERDA laboratories. We urge that procedures be adopted to encourage input from the laboratories at an early stage in the planning process and to allow timely review by the laboratories of plans nearing completion. Laboratory long-range plans such as this one will reach their ultimate usefulness only when they are closely reviewed by the ERDA managers and when there is substantive feedback on the plans from ERDA to the laboratories.

Need for Increased Program Flexibility and Breadth

At a time when many new ideas are being explored and rapid progress is desired, more flexibility and freedom of action should be given to the Laboratory. We favor a program that allows the Laboratory to shift funds, within reasonable bounds, between specific research and development targets within a broad program area. This flexibility could be used to encourage innovative ideas and to assure rapid growth in program areas where technological breakthroughs arise. A complementary step would be to encourage the submission and approval of form 189s that are fewer in number and broader in scope and that have an inherent flexibility of 5%.

Lead Laboratory

ERDA should establish "lead laboratories," especially in the new energy technology areas where rapid expansion of program is needed. In the lead laboratory role, ORNL would assume major management responsibility for a progam. It would subcontract substantial work to private industry and carry on a limited supporting research and development program within the Laboratory.

Foreign Travel

In many areas, foreign technology is more advanced than U.S. technology. Solutions to important elements of the energy problem will require open cooperation between the technological communities in many nations. In order to keep abreast of foreign development and to establish working arrangements for international cooperation, foreign travel by technical staff members is a vital necessity. In recent years, the trend has been to make it more difficult to get approval for foreign travel. This trend should be reversed.

V. SUMMARY OF FUTURE NEEDS

In this chapter, we present a realistic estimate of the resources ORNL will need to meet the goals set forth in the previous chapters of the Plan. Tabular information is given here on our required operating costs, support for facilities, and manpower. We also discuss briefly ORNL's space and computer requirements. This section should not be viewed in any sense as a budget document. The purpose of the section is to given an approximate picture of the magnitude of various program needs.

OPERATING COSTS

In Table V.1, a summary of the operating costs for programs at the Laboratory is given by ERDA subprograms. The information in this table is shown graphically in Figure 1 (in "Executive Summary"). The figures for FY 1977 are consistent with our best present knowledge of the FY 1977 Financial Plan for ORNL. All figures shown are in constant FY 1977 dollars. In compiling the figures presented in this chapter, the Laboratory management has tried to make realistic estimates of the amount of these programs that will finally be approved and to impose some constraints on the total growth of the Laboratory effort in various areas.

In the past, ORNL has typically been funded at a level which is 77% of the level requested in our budget proposals. The figures shown in Table V.1 very roughly represent that fraction of the total budgets. We have arbitrarily assumed that ORNL's research efforts in the basic energy sciences and biomedical and environmental sciences will remain constant during the period covered in the Plan. This assumption is made because as yet, we have not been given firm guidance from ERDA on the projected trends of these programs.

The growth in budgets shown in Table V.1 will not translate directly into growth in staff. At an increasing rate over the next few years, the national laboratories will assume a management role in ERDA's RD&D program. Large fractions of some programs will be put out on subcontracts to private industry and universities. We estimate that by FY 1983, $60 to $70 million of our operating budget will be spent outside the Laboratory.

FACILITIES

In Table V.2, the estimates of adequate funding for the maintenance and development of ORNL's plant and equipment are presented.

Programmatic Equipment

We believe that reasonable levels of support for programmatic capital equipment are 10% of the operating funds for established programs and 20% of the operating funds for new programs. In the past, ORNL's capital funds have been well below these levels. In FY 1976, our programmatic equipment budget was 6.5%. We strongly recommend a more liberal policy with respect to programmatic capital funds. Our needs are estimated in Table V.2.

General-Purpose Equipment

Because of inadequate funding for general-purpose equipment (GPE), much of our equipment is obsolete, and we have been forced to expend operating funds for maintenance on equipment that should have been replaced. The GPE funding has not allowed us to comply with ERDA criteria for replacement of equipment. Our estimated GPE needs are also shown in Table V.2.

General Plant Projects

In addition to providing funds for the needed expansion of office space, General Plant Project (GPP) funds are needed for improvements and minor additions to existing research facilities, for general plant improvements, and to provide adequate utility services. The need to increase funding for General Plant Projects has been described in the Hack Report.[1] Our GPP funds have been inadequate for a number of years, and a significant increase in the funding level is urgently needed. The estimated GPP needs for the Laboratory are given in Table V.2.

In a large plant such as ORNL, there is a large potential for reduced operating cost and reduced fuel consumption through good energy conservation projects. ORNL has made significant progress in the last few years in conservation through lowered thermostats, reduced lighting, etc. The greatest potential savings now are available through the installation of automated energy systems controls. We estimate that ORNL can make cost-effective improvements to our energy system through the use of GPE and GPP funds at the rate of

1. *Review of General Support Facilities for ORNL Research Programs (FY 1976-FY 1981)*, May 16, 1975.

Table V.1. Summary of operating cost (millions of dollars[a])

	1977	1978	1979	1980	1981	1982	1983
B. Fossil energy							
BA Coal	8.0	14.0	24.0	34.0	40.0	45.0	50.0
BB Petroleum and natural gas	0.6	0.7	0.6	0.6	0.4	0.4	0.4
BC In-situ technology	0.2	0.3					
	9.0	15.0	25.0	35.0	40.0	45.0	50.0
E. Solar, geothermal, and advanced energy systems							
EA Solar energy	0.6	0.8	1.2	1.5	1.7	1.9	2.0
EB Geothermal energy	1.1	1.3	1.4	1.5	1.5	1.5	1.5
EC High energy physics	0.4	0.4	0.4	0.4	0.4	0.4	0.4
ED Magnetic fusion energy	31.0	40.0	50.0	55.0	60.0	62.0	62.0
EE Basic energy sciences[b]	34.0	34.0	34.0	34.0	34.0	34.0	34.0
	67.0	77.0	87.0	92.0	98.0	100.0	100.0
H. Conservation							
HA Electric energy systems	0.5	0.6	0.7	0.8	0.9	0.9	0.9
HB Transportation energy conservation	0.1	0.1	0.1	0.1	0.1	0.1	0.1
HC Energy storage systems	0.7	1.3	1.9	2.0	2.2	2.4	2.4
HD Buildings and community systems	2.5	3.0	3.5	3.8	4.1	4.3	4.3
HE Interprogram activities		0.8	0.8	0.9	1.0	1.1	1.1
HF Conservation research and technology	0.1	0.7	0.7	0.8	0.9	0.9	0.9
HG Industrial systems	0.3	0.7	1.0	1.9	2.1	2.3	2.3
	4.0	7.0	9.0	10.0	11.0	12.0	12.0
K. Nuclear energy development							
KG LMFBR	12.0	13.0	16.0	16.0	15.0	14.0	12.0
KJ Nuclear research and applications	10.0	11.0	13.0	16.0	14.0	13.0	13.0
KX Fuel cycle R&D	18.0	28.0	33.0	36.0	39.0	39.0	37.0
KZ Special nuclear materials	3.6	6.0	6.0	5.0	4.0	4.0	4.0
	44.0	58.0	68.0	74.0	72.0	70.0	66.0
R. Biomedical and environmental sciences[b]							
RT Biomedical and environmental research	23.0	23.0	23.0	23.0	23.0	23.0	23.0
RU Environmental control technology	0.8	0.8	0.8	0.8	0.8	0.8	0.8
RW Operational safety	1.2	1.2	1.2	1.2	1.2	1.2	1.2
	25.0	25.0	25.0	25.0	25.0	25.0	25.0
Total ERDA	149.0	182.0	214.0	236.0	246.0	252.0	253.0
Total work for other agencies	38.0	38.0	37.0	35.0	31.0	28.0	27.0
	187.0	220.0	251.0	271.0	277.0	280.0	280.0

[a]All budgets are in constant FY 1977 dollars.

[b]Budgets assumed to be constant, pending further guidance from ERDA.

Table V.2. Facilities

	1977	1978	1979	1980	1981	1982	1983
Programmatic capital equipment	13.0	21.0	24.0	26.0	27.0	28.0	28.0
General plant projects[a]	3.7	5.8	5.6	6.2	6.4	7.3	6.5
General-purpose equipment[a]	2.2	3.9	4.1	4.2	4.2	4.2	4.3
Computers			12.0			12.0	
Experiments constructed on expense	13.0	26.0	30.0	29.0	24.0	22.0	21.0

[a]Includes $0.5 million/year designated for plant energy conservation projects.

$0.5 million/year. The budget projections for both GPE and GPP funds in Table V.2 include $0.5 million/year designated funds for energy conservation.

Computer Equipment

During the past year, an ad hoc committee was established to formulate a long-range plan for computing facilities at ORNL.[2] The committee consisted almost entirely of computer users. They first surveyed as many computer users as possible from the Laboratory staff to determine their estimates of computer requirements over the next five years. From the survey results, a projection of the total computer needs over the next five years was constructed. The projection of the total batch computing capability needed by all Union Carbide Corporation Nuclear Division operations in Oak Ridge is shown in Figure 3. The projected total UCCND needs for interactive computing capability are shown in Figure 4. The ORNL fraction of the total batch computing use in FY 1976 is 60%, and it increases to 86% in FY 1982. The ORNL fraction of interactive computing in FY 1976 is 39%, and it increases to 86% in FY 1982. The existing batch computing facilities were essentially saturated at the end of calendar 1976. The interactive capability has been greatly oversaturated. The addition of a PDP-10 KL-10 central processor early in FY 1977 is expected to provide adequate interactive computing in FY 1977.

The largest users of the batch computing facilities at ORNL in FY 1976 were Neutron Physics Division (35%) and Fusion Energy Division (17%). These same groups will be the largest users in FY 1982; Neutron Physics Division will generate 27% and Fusion Energy Division will generate 51% of the total batch computing need for FY 1982. For interactive computing, the Fusion Energy Division will play an even more dominant role. It is estimated that they will generate 80% of the interactive computing demand by FY 1982. Perhaps the largest uncertainty in these projects is the impact of relatively young programs in environmental sciences or information processing, which have a large potential for growth.

Based on these projected needs, an acquisition schedule for computing facilities has been recommended. The biggest items on the acquisition schedule are an interactive computer in the class of the IBM 370/168 in FY 1977 and a next-generation batch computer, such as the CRAY-1 machine, in FY 1979. In Figures 3 and 4, the dashed lines show the available computer capacity as a function of time, if this acquisition schedule is met. These figures show that if the new facilities are added on schedule, there will be computing capacity adequate to meet our needs over the next few years. However, the computer specified for FY 1977 has already been moved to the FY 1979 budget request, and the FY 1979 computer will be pushed back at least until FY 1982. There will be a significant computer shortage over the next several years. A temporary solution will be to shift some of the load to computers at other installations not yet saturated.

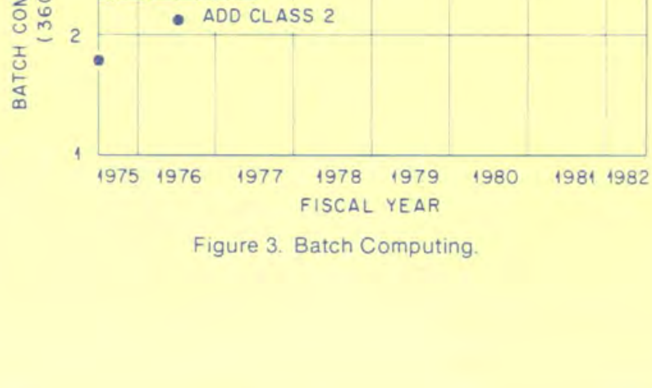

Figure 3. Batch Computing.

2. *Computing Facilities Long Range Plan—Oak Ridge National Laboratory 1976-1982*, March 1976.

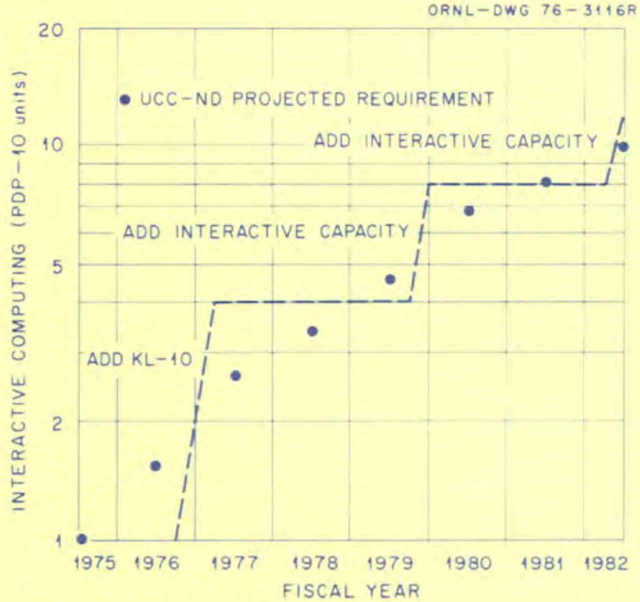

Figure 4. Interactive Computing.

Each of the proposed new computers will cost approximately $12 million.

Experiments Constructed on Operating Expense

There are several projects at ORNL that involve the construction of large equipment on operating expense. These include particularly the nuclear fuel cycle program, the Fusion Energy Division program, and potentially the fossil energy program. Our estimates of these expenditures are given in Table V.2. This is additional operating money, which will not result in personnel growth.

Personnel and Space

The projected number of regular full-time employees at ORNL for the period FY 1977 to FY 1983 is shown in Table V.3. The information in this table is shown graphically in Figure 2 (in "Executive Summary"). The personnel are projected for each ERDA program with the exception of Solar, Geothermal, and Advanced Energy Systems. In that case, the personnel are projected by subprogram because several of our major programs are in this one ERDA program. In addition to the personnel included in these projections, there are a large number of employees of UCCND's Computer Sciences and Engineering Divisions, temporary employees, and guests who are housed at ORNL. In FY 1977, there are about 1000 people in these categories at ORNL.

The projections shown in Table V.3 are realistic estimates of the personnel growth in the indicated programs. An average overall Laboratory staff growth of 2% has been assumed between FY 1978 and FY 1983. We have taken into account the fact that significant parts of some programs, primarily fusion and nuclear energy development, will be subcontracted outside the Laboratory or significant fractions of their operating funds will be for construction.

The personnel projections show a relatively modest increase in staff at ORNL by FY 1983. However, there already exists a serious space problem at ORNL. There is a shortage of offices, and many of the offices now in use are in antiquated buildings that must be replaced. Consideration is being given to renting private office space in downtown Oak Ridge to obtain some immediate relief from the space problem. We plan to obtain ultimate relief from space problems by constructing modular office buildings through GPP funding and some construction line items as discussed below.

At present, roughly 20% of the ORNL staff is housed at the Y-12 site. The remaining 80% is at the X-10 site. We review briefly here our plans for space development at each site.

Y-12 Site

The Biology, Fusion Energy, and Engineering Technology Divisions are housed at the Y-12 site; and the Chemical Technology, Analytical Chemistry, and Energy Divisions are partially housed at that site. An analysis[3] of the facility requirements for ORNL in the Y-12 area through FY 1979 indicated that programmatic growth in the Biology Division through FY 1979 can be accommodated by proposed modification, rehabilitation of facilities, and planned new facilities entirely within the present biology complex at Y-12. The expansion of programs in the Fusion Energy Division will require modification and considerable renovation of Buildings 9201-2 and 9204-1 to provide needed laboratory and office space. The Engineering Technology Division needs can be met with the proposed Engineering Technology Laboratory and the upgrading of existing space in Buildings 9201-3 and 9204-1. Anticipated new space requirements of the other ORNL divisions at Y-12 are relatively modest and can probably be accommodated in existing facilities.

3. Letter from R. F. Hibbs (UCCND) to R. J. Hart (ERDA, ORO), August 22, 1974.

Table V.3. Full-time equivalent manpower[a]

Program	1977	1978	1979	1980	1981	1982	1983
B. Fossil	190	350	500	650	750	820	880
E. Solar, geothermal, and advanced energy systems	1570	1650	1730	1790	1800	1810	1810
EA Solar energy	20	25	35	40	50	55	55
EB Geothermal energy	30	35	40	40	40	40	40
EC High energy physics	10	10	10	10	10	10	10
ED Magnetic fusion energy	560	630	695	750	750	755	755
EE Basic energy sciences[b]	950	950	950	950	950	950	950
H. Conservation	80	100	120	130	140	150	150
K. Nuclear energy development	1130	1180	1200	1150	1100	1050	1030
R. Biomedical and environmental sciences[b]	730	730	730	730	730	730	730
Total ERDA	3700	4010	4280	4450	4520	4560	4600
Total work for others	700	630	570	530	510	510	500
	4400	4640	4850	4980	5030	5070	5100

[a]Full-time equivalent manpower includes all regular full-time employees on ORNL payroll. In 1977, there are at ORNL an additional 1000 people who are guests, temporary employees, or personnel from the Union Carbide Corporation Nuclear Division Computer Sciences and Engineering Divisions.

[b]Assumed to be constant, pending ERDA guidance.

X-10 Site

A serious shortage of office space at ORNL will exist if our GPP funds are not adequate and if our line items are not given timely approval. A major facility, the Environmental Sciences Building, is now under construction and should meet our most pressing needs. We have proposed an Energy Systems Research Laboratory (ESRL) as a line item in FY 1979, and we will propose an Information Center Complex building sometime after FY 1979. The Laboratory's space needs should be met with these three buildings, plus the rental of some private offices, as discussed previously.