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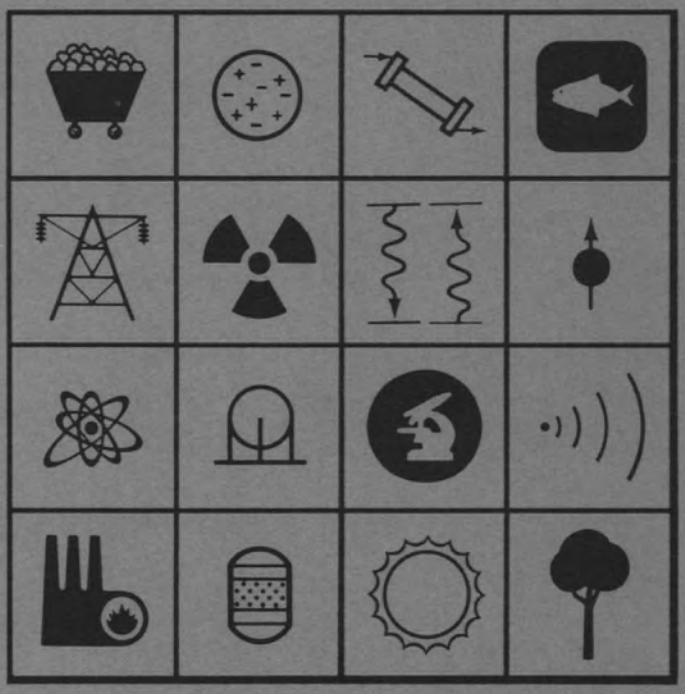
OAK RIDGE NATIONAL LABORATORY INSTITUTIONAL PLAN

FY 1980 - FY 1985

November 1979
(Revised March 1980)



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coal	plasma	rotary drum dryer	fauna
transmission tower	radioactive	radiative and absorptive transition	particle spin
atom	pressure storage tank	laboratory	wavefronts
steam power	fluidized-bed reactor	insolation	flora

ORNL/PPA-79/8R1

OAK RIDGE NATIONAL LABORATORY INSTITUTIONAL PLAN

FY 1980 - FY 1985

DATE PUBLISHED MARCH 1980

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OAK RIDGE NATIONAL LABORATORY
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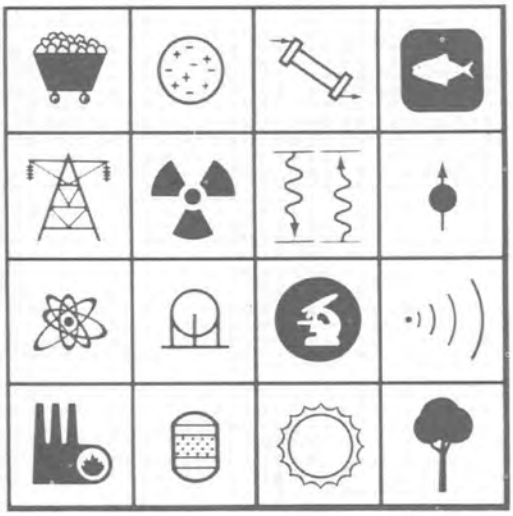

Oak Ridge National Laboratory (ORNL) is operated by Union Carbide Corporation, Nuclear Division (UCC-ND), which is the Department of Energy's (DOE's) largest contractor organization. As a result, the Laboratory has several unique features: (1) an industrial management perspective and contacts; (2) a production capability; (3) a multisite location with a variety of unique physical resources; (4) extensive engineering and computing support; and (5) together with Oak Ridge Operations, a successful background in managing immense construction and demonstration projects. ORNL is located in the Southeast, a fast-growing region showing unusual receptiveness to change. Furthermore, the proximity of ORNL to the Tennessee Valley Authority (TVA), whose management actively seeks cooperation in new developments and demonstrations, presents a unique opportunity to the Laboratory and DOE.

ORNL stresses the selection of important energy technologies that require applied development and engineering to take them to practical application but that also need strong support from basic areas of physical, environmental, social, and biological sciences and engineering. The simultaneous application of the applied sciences (such as materials sciences, chemical engineering, measurement sciences, impact analysis, biological testing, and environmental assessment) is a crucial constituent of the ORNL approach.

The last several years have seen significant changes at ORNL: it has evolved from a laboratory that was once almost wholly nuclear to one that now includes

Director's Overview

large efforts in the nonnuclear technologies. At the same time, the basic physical and life sciences supporting the technologies have also shifted their emphasis from nuclear to nonnuclear through changes of people, approaches, and management directions within the constraint of very limited growth.

The growth in the Laboratory's research and development (R&D) has occurred mainly in the technologies and has been accompanied by major new emphases in the sciences. ORNL has also made major shifts in modes of operations, deliberately attempting to increase its outreach in the Southeast, to subcontract a much larger portion of its R&D, to undertake program management for DOE in several crucial areas, and to employ industrial points of view and capabilities through subcontracting and through advisory groups. The Laboratory is also making use of its diverse expertise and experience by devoting more effort to studies, assessments, and information services.

The Laboratory is developing some new long-term objectives calling for closer collaboration with TVA, universities, and industry. In particular, the Laboratory would like to assist in providing more liaison between federal (especially DOE) R&D programs and the long-term research needs of industry. This role is becoming more and more important as U.S. industry increasingly shifts towards research that is defensive or aimed at fulfilling regulatory requirements and away from long-term, high-risk research aimed at innovative, competitive new products. One example of this is the Laboratory's wish to build and use in collaborative programs a unique facility for long-term, high-temperature materials research—the High Temperature Materials Laboratory.

The increased emphasis on institutional planning at this and other laboratories—typified by the onsite reviews of the laboratories' preliminary plans by their responsible assistant secretaries—is a welcome development. However, continued efforts are needed to emphasize the strategic nature of these plans and to minimize their misuse as substitutes for budgetary plans.

Herman Postma, Director

...atory
issues

Laboratory Trends and Issues

This chapter highlights important changes projected for ORNL for the period from 1979 to 1985 and brings them to the attention of the appropriate secretarial officers of the Department of Energy (DOE). Discussed are (1) changes in programmatic mix; (2) shifts in emphasis within the basic sciences programs; (3) the growth of extramural expenditure; (4) a continuation of the current increased activity level in certain non-research and development (R&D) tasks (onsite waste, safeguards, studies and assessments, and program management); (5) the continued growth of cooperative and collaborative activities, especially with the Tennessee Valley Authority (TVA) and universities; (6) a closer tie to industry's generic energy R&D; and (7) a positive solution to some of the Laboratory's facility needs.

A subsequent chapter contains more detailed discussions of the programmatic activities.

Personnel Planning Levels

According to the history and projections of personnel numbers at ORNL, which are shown in Fig. 1, the Laboratory's population declined rapidly from 1968 to 1974 but then showed strong growth. The trend has now changed again so that the current and projected levels show relatively little growth: the planning level for both FY 1980 and FY 1981 is 5180 full-time equivalents (FTEs), and the projections in this plan show only a very small growth (about $^1/_2$% per year) for the period from 1981 to 1985. However, some increase over these levels may be sought if new work is required in support of the Nuclear Regulatory Commission (NRC), perhaps as a result of the Three Mile Island accident, or if other substantial new programs are undertaken.

Extramural Expenditure

The Laboratory's extramural expenditure has grown markedly in the last five years, and this strong trend is expected to continue in the near term and to level off in the later planning years. Although the amount of money spent on procurement of major items has increased, that spent on R&D subcontracting has accounted for most of the growth in ORNL's extramural expenditure (Fig. 2); this reflects the Laboratory's policy, effective since 1975, of increasing its subcontracting. Subcontracting of ORNL work is advantageous because it (1) increases R&D capability without increasing staff, (2) brings the expertise of industry and universities to bear on ORNL's R&D problems, (3) is an effective method of technology transfer, (4) provides for flexibility and faster response, and (5) answers DOE's current need for the national laboratories to undertake more program management on its behalf.

Partly because of DOE's decentralization thrust, universities and other national laboratories are now most rapidly increasing their share of this subcontracted R&D (Fig. 3), although the industrial sector still accounts for more than 60% of the Laboratory's subcontracted funds. Industry's tasks are divided about equally between conducting R&D leading to products (especially hardware) and performing studies and evaluations.

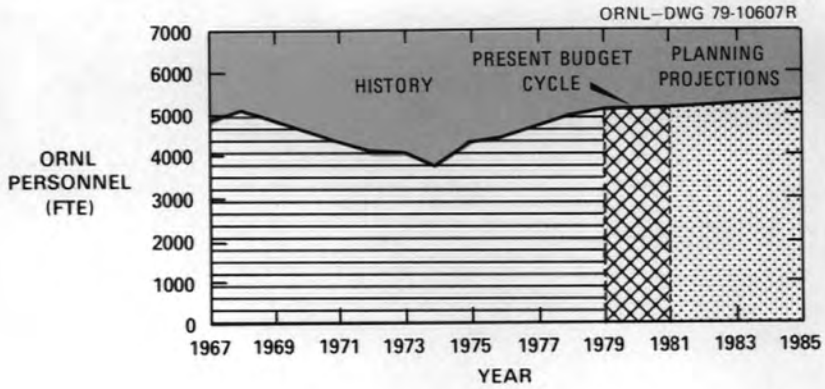

Fig. 1. ORNL personnel levels, both current and projected, show little growth.

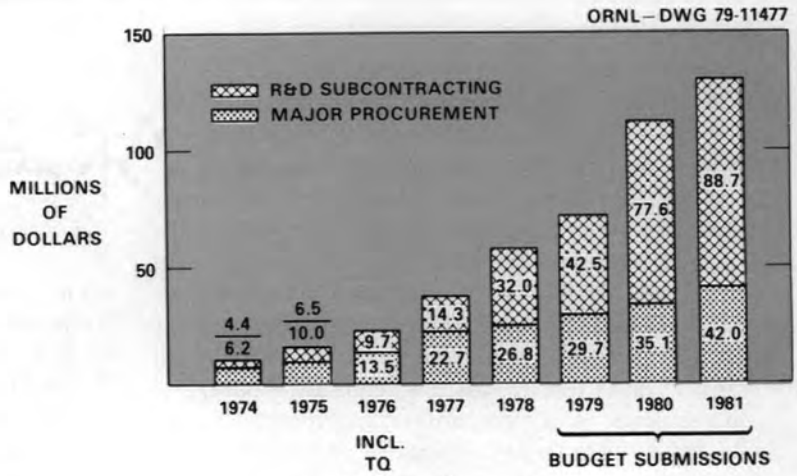

Fig. 2. Growth in R&D subcontracting and other extramural expenditure has been substantial and is expected to continue.

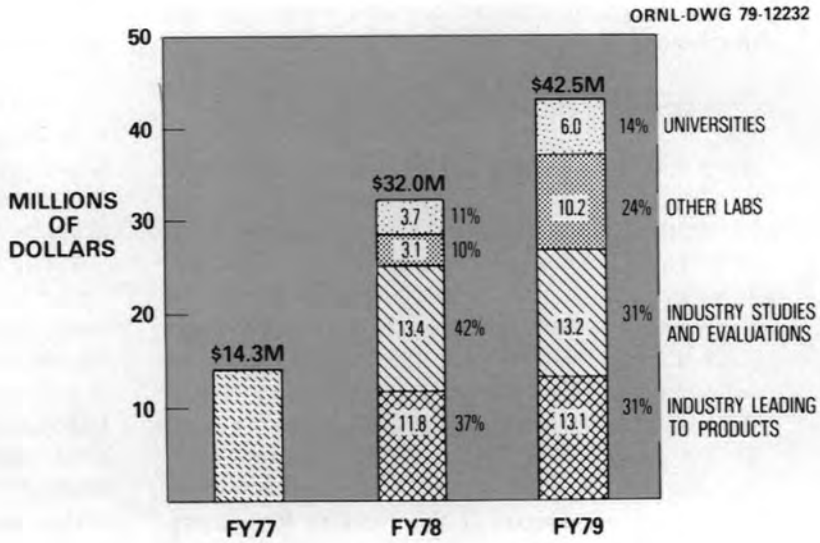

Fig. 3. The Laboratory's R&D subcontracting to universities and other laboratories is increasing.

Studies have shown that a laboratory is most effective if about 20 to 50% of its total funding is used for subcontracting. ORNL is not yet in danger of committing too much to this kind of activity, nor will it be within this planning period: we anticipate that no more than one-third of the Laboratory's funding will eventually be used in this management effort. However, 20 to 50% is an overall figure that may not apply to all types of subcontracting.

Generally, the Laboratory accepts a management role only if (1) it can bring some special, needed technical expertise to the task; (2) at least 15% of the technical program associated with the task is carried out in-house; and (3) it views the task as fulfilling important national objectives.

TVA

S. David Freeman, chairman of the TVA Board of Directors, has invited ORNL to form a much closer relationship with TVA, particularly in research and demonstration activities. In the past, active collaboration between the two organizations has been minimal—indeed, almost nonexistent. However, following this initiative and with the active support of the Oak Ridge Operations Office (ORO), the Laboratory has had extensive discussions with TVA at all levels, and many mutual interests and programs have been defined. As a result, several collaborative programs have already begun and more are expected. Important areas of cooperative effort include environmental effects and control, materials, uranium recovery from phosphates, load management, reactor utilization and control, and data management. Programs in these areas reflect the genuine complementarity of the Laboratory's research capabilities and TVA's role as a demonstration utility for new technologies.

University Interactions

One of the Laboratory's major long-term objectives, which was first explicitly stated during this year's institutional planning round, is to seek closer relationships with the university community. As a part of this effort, the Laboratory will develop its partnership with Oak Ridge Associated Universities (ORAU). This is not to say that there have been no such interactions in the past; indeed, ORNL has had a long history of cooperation with universities in educational and research programs, especially in the Southeast and through ORAU.

The Laboratory's primary objective in its university cooperative research and training is to help ensure adequate personnel for energy R&D programs, which complement those of the academic institutions. Furthermore, besides providing unique opportunities for cooperative research with the university community, the programs fit within the Laboratory's programmatic goals and effect a transfer of scientific and technical information. In FY 1978, ORNL had guest programs (some of which were carried out in cooperation with ORAU) involving 286 undergraduates, 288 graduate students, 60 postdoctoral fellows, and 132 visiting faculty. A summary of the guest assignments in 1978 shows that almost all were university staff or students, although a few industrial personnel were also included. In addition to the guest assignees, almost 500 consultants from universities work intermittently at the Laboratory and are paid by either ORNL or ORAU.

Another thrust during this planning period will be the increased use of unique ORNL facilities by outside groups, especially universities. Several user-oriented facilities already exist at the Laboratory, including the small-angle x-ray diffraction facility, which is partially funded by the National Science Foundation (NSF), and the isochronous cyclotron. The new Holifield Heavy Ion Research Facility (HHIRF) will be operated as a user facility, involving researchers from more than 70 universities, and will be an important addition to the universities' research capability.

Still another sign of the Laboratory's increased university interactions will be the growth of its R&D subcontracting to universities (Fig. 4).

Program Management and Assessment Activities

Since 1974, when the Laboratory was at its smallest recent size (3900 FTEs), growth has occurred in all research categories. Two areas in particular have grown in relative importance. The management of technical programs on behalf of DOE has grown from a staff of 8 in 1974 to the current equivalent of 50 scientific personnel. Assessments, studies, and information services have grown from about 260 staff members in 1974 to about 520 staff members in the Laboratory's research divisions (and perhaps 50% more working in industry under subcontracts). Some further increase is expected during this planning period, but at a much lower rate (Fig. 5).

Between 1974 and 1979, the ORNL staff increased by about 1300 FTEs, less than half of which are in support services. As in other areas, much of the

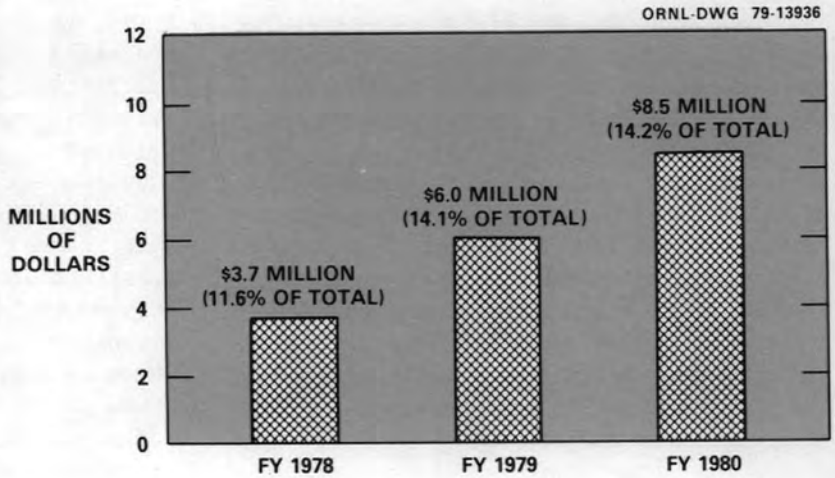

Fig. 4. The Laboratory's R&D subcontracting to universities is increasing in absolute terms and as a percentage of total ORNL R&D subcontracting.

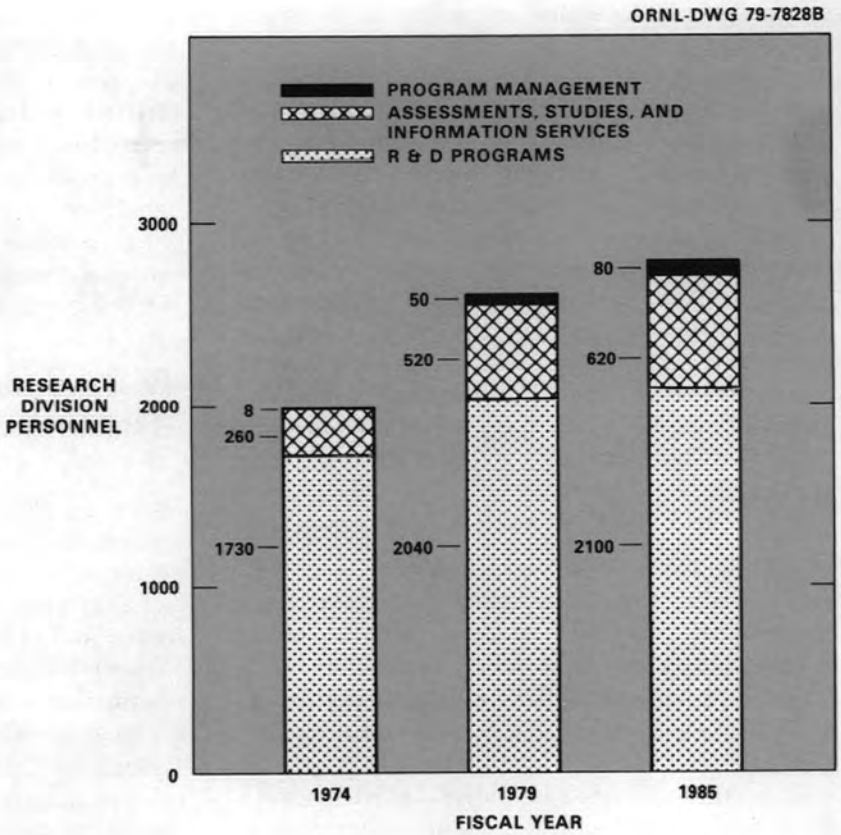

Fig. 5. The number of research staff engaged in all categories of work continues to increase.

increase in technical staff has been in activities other than "traditional" direct R&D. Some of the staff, such as safeguards personnel and those handling wastes from the former Manhattan Engineering District (MED) and the Atomic Energy Commission (AEC), have been necessitated by DOE or other outside requirements, as is illustrated in the following table:

Activity	Growth for 1974 to 1979 (Direct FTEs)
ORNL Safeguards	25
Waste from MED and AEC	30
DOE program management	40
Studies, assessments, and information services	260
Direct R&D	310
Support services	645
Laboratory total growth	1310

Programmatic Mix

In the past five years, the major technology-oriented programs (fission, fusion, fossil, and conservation) have assumed a larger proportion of the Laboratory's activities, while programs in the basic physical and life sciences have assumed a smaller proportion (Fig. 6). During this planning period, fusion and fossil programs are expected to become even more important activities at ORNL, but basic physical and life sciences programs will decrease only slightly (Fig. 7). The "other" category in this figure includes some of the small, but growing, programs in nonnuclear energy.

About 20% of the Laboratory's direct FTEs are currently engaged in work for non-DOE sponsors. Almost half of them are in NRC programs, and most of the remainder are in various life sciences programs for the Environmental Protection Agency (EPA), the Department of Health, Education, and Welfare (HEW), and the National Cancer Institute. Current projections show a substantial reduction in NRC programs, which is only partially offset by a modest increase in non-DOE support for the life sciences; the more basic life sciences work, in particular, is not receiving adequate DOE funding. As a result, we expect non-DOE work to fall from about 20% to less than 16% of the Laboratory's effort during this period (see the following table). These projections, however, do not include any large new NRC programs that might be required, perhaps as a result

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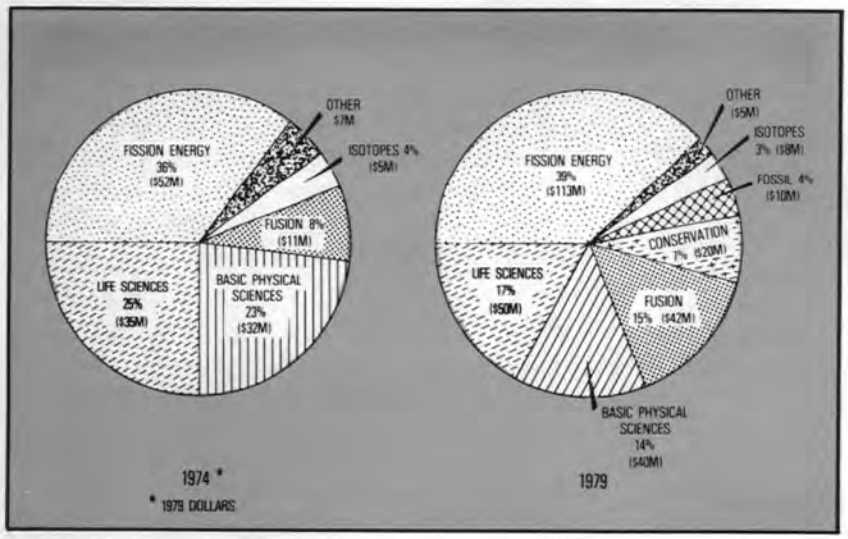

Fig. 6. Since 1974, the technology-oriented programs (fission, fusion, fossil, and conservation) have assumed a larger proportion of the Laboratory's operating funds, while programs in the basic sciences have assumed a smaller proportion.

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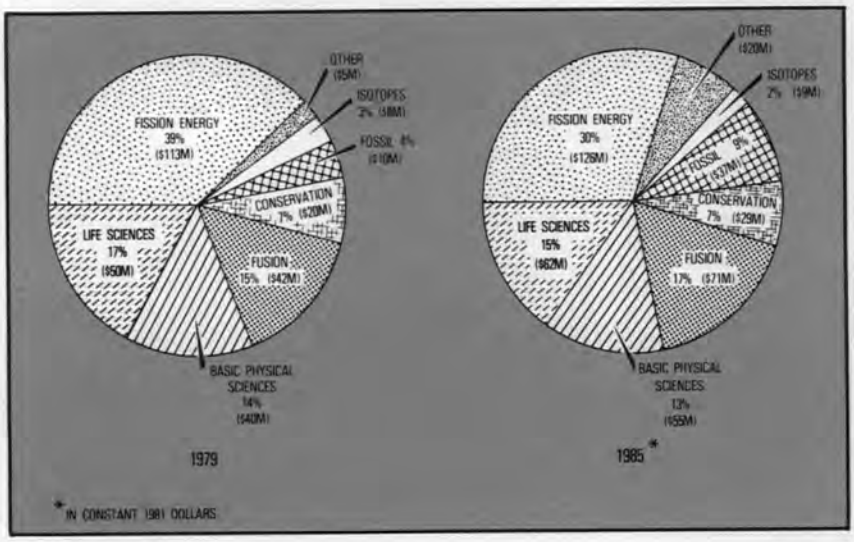

Fig. 7. Fusion and fossil programs are projected to increase in proportion to other Laboratory activities by 1985.

of the Three Mile Island accident, and that would need additional personnel to implement.

Summary of Non-DOE-sponsored FTE[a]

	'79	'80	'81	'82	'83	'84	'85
Total direct FTE	2321	2520	2518	2554	2582	2607	2630
Non-DOE-sponsored FTE	436	460	409	400	407	413	420
Percentage of non-DOE-sponsored FTE	18.8	18.3	16.2	15.7	15.8	15.8	16.0

[a]Full-time equivalent (FTE) person-years.

Fission

Still the largest single R&D area at the Laboratory, fission R&D currently emphasizes (1) studies and evaluations of nonproliferating fuel cycles for the Nonproliferation Alternative Systems Assessment Program (NASAP) and the International Nuclear Fuel Cycle Evaluation (INFCE) program, (2) R&D on advanced fuel reprocessing techniques, (3) the evolution of remote fabrication techniques in accordance with nonproliferating cycles, (4) the thorium cycles, (5) research for the Liquid-Metal Fast Breeder Reactor (LMFBR) Base Program, (6) the high-temperature gas-cooled reactor (HTGR) advanced converter, and (7) the gas-cooled fast breeder reactor (GCFR). We are increasingly involved with the management of local radioactive waste and with technical support provided for other lead laboratories in the waste programs. We are heavily involved in LMFBR R&D in special areas in support of various parts of the national programs.

We expect an overall decline in the fission program, although our major lead laboratory role in managing all reprocessing R&D under the Consolidated Fuel Reprocessing Program (CFRP) should continue to grow somewhat. We expect more concentration on fuel reprocessing for breeder reactors and increased emphasis on engineering methods to inhibit proliferation, on low-level waste management, and on support of base technologies. Also anticipated are a slight decline in the breeder support program and possibly a major decline in the space program. The HTGR national program is currently being reevaluated. National planning is now focusing on activities necessary to formulate specific plans that may lead to a reactor demonstration program. If this materializes, it will undoubtedly result in significant increases in HTGR work at ORNL.

Fossil

The Laboratory began its fossil program five years ago with the Office of Coal Research. The program became one of the fastest growing at the Laboratory, encompassing areas of process and engineering evaluation, availability of critical components, support to the Solvent Refined Coal (SRC) process, research in atmospheric fluidized-bed industrial-sized boilers, and supporting research in the environmental and energy sciences.

As a result of last year's institutional planning round, we expected to assume a major role in the coal program, involving work with the Pittsburgh Energy Technology Center (PETC), the Morgantown Energy Technology Center (METC), and TVA. In fact, the coal program was singled out for particular growth in last year's *Institutional Plan.* The Laboratory was given a lead mission assignment in materials for fossil energy systems and a coordinating role in environmental research and assessment. Implementation of these plans has been slow, but the Laboratory's role in the coal program was reconfirmed during this year's onsite institutional planning review and is beginning to develop more rapidly.

Fusion

Since 1969, the fusion program at ORNL has emphasized tokamaks and the technologies supporting them. The Laboratory has played a leading role in the development of neutral beam heating, including its demonstration on the Oak Ridge Tokamak (ORMAK) and the Impurity Study Experiment (ISX) at Oak Ridge and on the Princeton Large Torus (PLT) and the upcoming Poloidal Divertor Experiment (PDX) at Princeton. We also have major responsibilities for large superconducting coils and materials, and the Engineering Test Facility (ETF) design center is located here. The ELMO Bumpy Torus (EBT), an ORNL concept, has recently been designated as the leading alternative to tokamaks and mirrors, and we have been assigned the management responsibility for strong industrial participation in the design, construction, and operation of the proof-of-principle experiment, EBT-P. We hope that the ORNL fusion program will include a superconducting long pulse tokamak to test the nearly steady-state features of tokamaks and will emphasize engineering and technology as well as a shielded neutral beam test facility for the development of ETF neutral beams. These activities are in accordance with the recent Foster report that outlines the strategy of fusion development.[1] The ORNL fusion budget will continue to expand, largely because of EBT-P and subcontracts, but the growth in staff will be modest.

[1]Department of Energy, *Final Report of the Ad Hoc Experts Group on Fusion to the Fusion Review Committee,* DOE/ER-8000, June 1978.

Conservation

Our contributions in conservation began with NSF funding in the early 1970s. Since then, support has been provided by the Department of Housing and Urban Development (HUD), the Federal Energy Administration (FEA), and the Energy Research and Development Administration (ERDA); it is now provided mainly by two secretarial offices within DOE—Energy Technology and Conservation and Solar Applications (Fig. 8). The Economic Regulatory Administration (ERA) and the Energy Information Administration (EIA) also support work in the Laboratory's conservation program, primarily in the fields of modeling, model validation, and data validation. Most recently, the program has focused on managing technology outreach programs, particularly those related to residential and commercial heat pumps and appliances, thermal envelopes, innovative structures, thermal energy storage, and utility load management.

Overall, we expect the conservation program to grow more slowly than it has in the past few years. Work in load management, industrial energy conservation, low-temperature cycles, cogenerative systems, and biologically based chemical process systems will continue to expand. Much of this expansion, however, will be accomplished through subcontracting rather than through increases in ORNL staff.

Solar and Geothermal

ORNL's involvement in the geothermal and solar programs is relatively limited. In the woody biomass program, though, our location in the Southeast and our strong ecological group give us a unique capability. Furthermore, recent work in our Solid State Division has led to new techniques and insights that are expected to prove valuable, in the long run, to photovoltaic conversion concepts. We shall continue to use our talents and facilities wherever they can make useful contributions to geothermal technology and shall especially encourage good new ideas at the Laboratory that can further DOE's work in solar energy.

Life Sciences

The emphasis in DOE-funded basic life sciences work at ORNL has dramatically shifted from nuclear- to nonnuclear-related work. This trend is expected to continue, although at a much lower rate, throughout this planning period (Fig. 9) because of

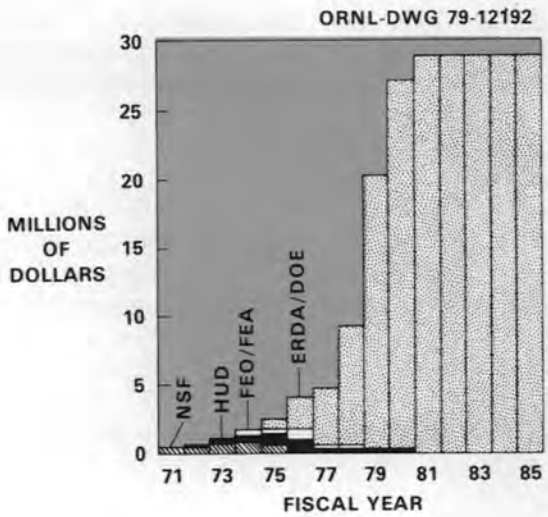

Fig. 8. The Laboratory's conservation program has expanded rapidly but is expected to stabilize in future years.

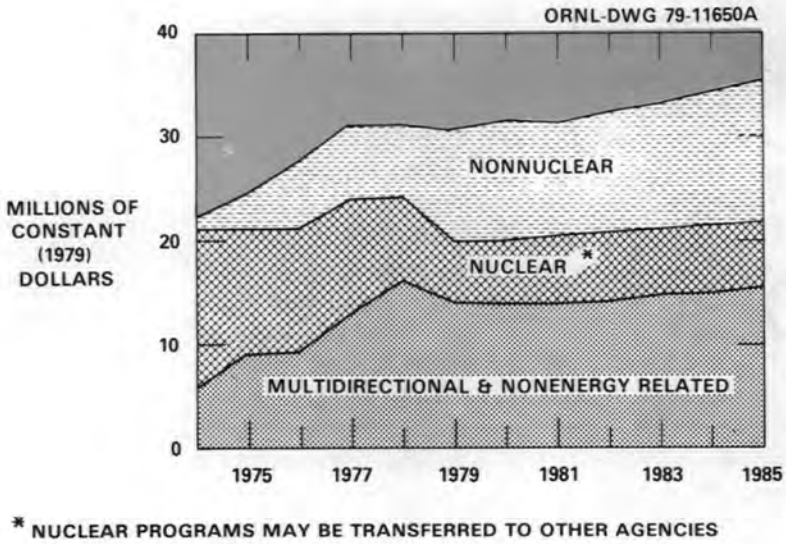

Fig. 9. The emphasis in DOE-funded life sciences work is changing from nuclear to nonnuclear.

the projected continued growth in research related to the nation's fossil energy programs. A reawakening of research in radiobiology, however, might reverse that trend in later planning years.

Work performed for other federal agencies (especially HEW, EPA, and NSF) as a part of the integrated basic life sciences programs at ORNL is also important. Support from these sources has been and will continue to be essential to maintain the Laboratory's strength in the basic life sciences; it also helps to provide the necessary overall institutional and programmatic flexibility. Currently, about one-third of ORNL's life sciences work is supported from outside DOE—a proportion that could increase if some of the radiation research programs for which DOE is responsible are shifted to other agencies.

Basic Physical Sciences

The orientation of research in the physical sciences has also changed markedly as the Laboratory has sought to provide the increased support necessary for the new nonnuclear programs while staying within essentially constant budgets. In the future, this trend is expected to continue but at a slower rate and, as a result of an increase in funding, should not reflect a decline in nuclear research. Most of this increase will be used to support nonnuclear and fusion energy work, while the other areas (fission energy, nuclear physics, and facility operation and support) are held more or less constant (Fig. 10). An increase in facility operation and support is anticipated because of the HHIRF startup.

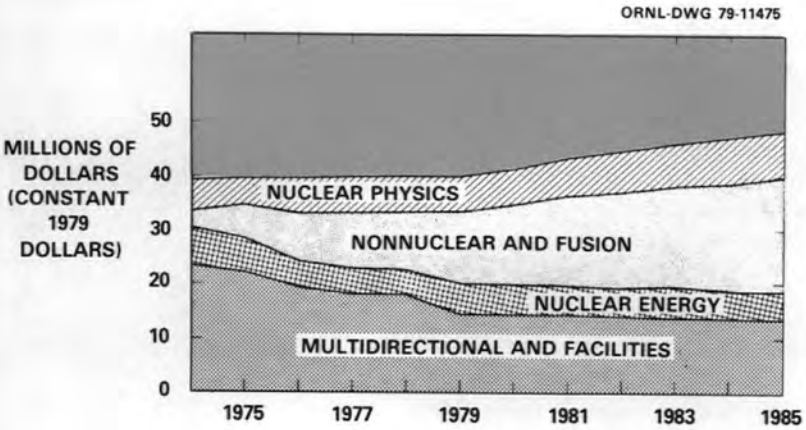

Fig. 10. The emphasis in basic physical sciences funding has changed from nuclear- to nonnuclear-related activities.

Facilities

The Laboratory is requesting funding for two major new building projects, the High Temperature Materials Laboratory (HTML) and the Energy Systems Research Laboratory (ESRL). Intended as a national resource for performing and investigating difficult property measurements at high temperatures, the HTML will be used by industry, universities, and the national laboratories for collaborative and joint research. Such research is important to all energy technologies and has been identified as a generic area that is also important to industry.

The ESRL is not only a proposed major addition [9,000 m^2 (97,000 ft^2)] but also the first general facility to be built since 1953. It is needed because space requirements and aging of original Laboratory buildings are hampering the efficient execution of our programs. About 25% of the offices are substandard in space or quality; laboratories have such problems as inadequate height, floor loading, and temperature control; and organizational units, particularly the Energy Division and the coal program, are physically divided. The ESRL will provide critically needed laboratory and office space, especially for the fossil energy, conservation, and biotechnology programs.

It must again be observed that general plant project (GPP) funding has been at the same dollar level for a decade and is grossly inadequate to maintain the current facilities acceptably. Therefore, we are again seeking some increase in GPP funding in our budget submissions and projections, if only to bring ORNL up to a level comparable to those of other DOE laboratories.

ORNL Lead Missions

Fission [Energy Technology (ET)]

Consolidated Fuel Reprocessing Program (Current)
Nuclear Standards Management Center (Current)
Materials and Structures Technology Management Center (Current)
Low-Level Waste Management Program (Associate lead mission)

Fusion Energy (ET)

ELMO Bumpy Torus Research and Development (Proposed)
Laboratory Engineering Test Facility—Planning and Preconceptual Design (Proposed)
Superconducting Coils for Toroidal Confinement Systems (Proposed)

Fossil Energy (ET)

Fossil Energy Materials Program (Current)
Coal Effluent Technology (Proposed)
Supercharged Fluidized-Bed Combustor Program (Proposed)

Conservation (ET)

Power Systems Technology (Current)

Other ET

Environmental Impact Assessment for Fossil and Geothermal Energy (Current)

Conservation (Conservation and Solar Applications)

Residential and Commercial Conservation in Buildings and Appliances (Current)

Environment (Environment)

Environmental Research for Gasifiers in Industry and H-Coal (Current)
Ecosystem Modeling for Regional Environmental Resource Analysis (Current)
Integrated Regional Assessments for Regions 4 and 6 (Current)
Environmental Impact Assessment for Nuclear Fuel Cycle and Waste Management (Proposed)
Nonnuclear Solid Waste Technology (Proposed)

Basic Physical Sciences (Energy Research)

Experimental Program Management for the Holifield Heavy Ion Accelerator (Current)
Experimental Program Management for the High Flux Isotope Reactor (Current)
Analysis of Basic Research Underlying Fossil Energy Technologies (Under development)

Small-Scale Hydroelectricity (Resource Applications)

Environmental Analysis and Research for Small Hydroelectric Technology (Current)

Data and Model Validation (Energy Information Administration)

Fossil Energy Technology and Consumption Data Systems and Model Validation (Current)

Scientific and Technical Activities

Assistant Secretary for Energy Technology

The Assistant Secretary for Energy Technology is the major supporter of programs at ORNL and was responsible for over half the Laboratory's work in FY 1979. Conducted on his behalf are programs in fission energy, magnetic fusion energy, fossil energy, nuclear waste, conservation, solar energy, and geothermal energy. The fossil energy program is one which has grown rapidly in the last few years and is now of major importance at the Laboratory. Specifically, the Department of Energy's (DOE's) intention to use ORNL as a chief resource in the fossil program was confirmed during the onsite review that began this planning round. This section provides a description of each program, focusing on the technical thrust of each program and including, if applicable, major changes, issues, or results anticipated.

Magnetic Fusion Energy

Technical Thrust

Recently, substantial advances in tokamak development have occurred, partly because of the neutral beam technology developed by ORNL. While continuing its research on the tokamak, DOE intends to continue its exploration of a range of magnetic fusion devices. In accordance with DOE policy, the Laboratory proposes to continue its role in tokamak and ELMO Bumpy Torus (EBT) confinement experiments, which supply plasma physics information and provide for essential physics technology integration. We also plan to maintain our position with respect to the development of superconducting coils and neutral beams, materials development, and the Engineering Test Facility (ETF) design center. These activities will lead to a substantial increase in subcontracting and programmatic involvement with industry but only a modest growth in the ORNL fusion staff.

The fusion program at ORNL participates in nearly all phases of the national toroidal program and is unique in its breadth. This broad effort in plasma physics experiment, theory, and technology development is carried out in the context of advanced design activities and gives ORNL a major role in the effort to develop fusion as a viable energy option.

Confinement Systems (AF 01). The study of impurities and the plasma-wall interaction, which was initiated on the Impurity Study Experiment, ISX-A, is being continued on ISX-B, a modification of ORNL's second tokamak. The ISX-B device will seek to maximize the plasma pressure (beta) in a tokamak with an elongated cross section and neutral injection heating. An alternative heating technique—electron cyclotron resonance heating (ECRH)—was tested in FY 1979. Although its short pulse length (about 0.1 to 0.25 sec) is sufficient for establishing plasma physics theory-experiment correlations, the ISX cannot provide the long pulse demonstration required for proceeding to a fusion reactor. Thus, the Long Pulse Technology Tokamak (LPTT) is proposed as a continuation of the ISX program in order to provide the required pulse

lengths of 10 to 20 sec. Approval is expected for FY 1980 or FY 1981, and operation should begin by FY 1984 or FY 1985.

The EBT concept, which originated at ORNL and is a leading alternative to the tokamak concept, will be further validated in the EBT-S. The device is a modification of the earlier EBT device and provides a higher magnetic field and higher microwave power. In addition, DOE has selected the EBT concept for advancement to the proof-of-principle phase. Project definition studies by industry and ORNL were initiated in FY 1979 and will be completed in FY 1980. From these studies, the EBT-P, which will represent the proof-of-principle phase, will be defined for approval in FY 1980. ORNL will manage the program, but industry will have the principal design and fabrication responsibility. In FY 1980, DOE will select the site for the device, which should be operating by FY 1984. While the design and fabrication of the EBT-P is progressing, the EBT-S experimental program will be significantly expanded to support the EBT-P. Included will be a program of ion cyclotron resonance heating (ICRH) experiments, fabrication and testing of auxiliary aspect ratio enhancement (ARE) coils, and other experiments for improvements in confinement characteristics. During the same period, industry's involvement in the operation of the EBT-S will also increase significantly.

Development and Technology (AF 02). The major emphasis in this area will be the development and operation of a large superconducting coil array in the Large Coil Program (LCP) and the development of advanced neutral beam systems. Planning studies for the ETF have shown that a shielded neutral beam test facility will be needed at an early date to meet ETF neutral beam requirements. In addition, significant work is in progress on (1) the development of materials for fusion reactors, (2) the development of accelerators for solid hydrogen pellets for fueling plasma devices, (3) the characterization of the plasma-wall interaction, and (4) the development of techniques for calculating neutron transport in complex geometries and for checking the calculations against experiment. For both the plasma physics experiments and the technology development, design studies for tokamak and EBT demonstration power reactors and for the ETF serve as a focus. We have also begun work on a Generic Environmental Impact Statement for fusion power systems.

Applied Plasma Physics (AF 03). Through the theoretical plasma physics program, we will continue our efforts to create and exploit theories and models of plasma behavior. Program results provide a framework for understanding current experiments as well as a basis for the design of advanced tokamak and EBT devices. Having demonstrated the theoretical credibility of high-beta tokamak devices, the theorists will carefully study the ISX-B experiments to determine whether the theories of ideal and resistive magnetohydrodynamics modes, kinetic instabilities, and plasma transport are adequate and to develop refinements if new physics phenomena appear. Similar development of reliable models is needed for EBT systems to enable study of particle confinement, plasma transport processes, self-consistent electric and magnetic fields, microinstabilities and fluid instabilities, and the physics of hot-electron rings. Available tools for analyzing fusion burn processes, divertors, plasma heating and fueling, and the interaction between the plasma and the confinement structure must be improved for EBTs and tokamaks for use in determining the detailed design of the LPTT, the ETF, the International Tokamak Reactor (INTOR), and reactor-scale devices.

Major Issues

As stated, the ORNL fusion program is unique in its breadth and is making broadly based contributions to the advancement of fusion power. Continuation of this effort requires a major confinement experiment to provide focus and integration for the program as a whole; the EBT-P and the LPTT are needed to facilitate this experimentation.

Major Results or Milestones

During this planning period, we hope to achieve numerous milestones. Preliminary data from the ISX-B experiment were obtained in FY 1979; by early FY 1981, the experiment should yield definitive information providing an understanding of the maximum attainable beta in a noncircular tokamak. Pellet-fueling studies and experiments on the ISX-B, which will be based on current, successful single-pellet injection methods, should produce techniques for continuous fueling in FY 1981. The addition of increased neutral beam power is planned for FY 1980; a bundle divertor for impurity control will be added the following year. Also in FY 1980,

preliminary data will be available from the ECRH experiments initiated in FY 1979. During FY 1981 and FY 1982, several hundred kilowatts of additional ECRH power will be installed, and relativistic beam injection experiments will be conducted.

The scaling of confinement effects with microwave power and frequency will be measured on the EBT-S. Results from experiments at 28 GHz and a power level of 50 to 75 kW will be available in early FY 1980; an increase in power to 300 to 400 kW is expected by the end of FY 1981. If operation at 28 GHz is successful, we will begin ARE experiments in late FY 1980. Studies of ICRH, also to begin in FY 1980, will be completed in FY 1981. Project approval for the EBT-P is expected in FY 1980.

We will complete development of the Poloidal Divertor Experiment (PDX) neutral beam line in mid-FY 1980: the required parameters are an energy level of 50 keV, a current of 100 A, and a pulse length of 0.5 sec. Also in FY 1980, a long pulse ion source compatible with the beam line of the Tokamak Fusion Test Reactor (TFTR) will be developed.

The first two LCP coils will be delivered in late 1980, and testing will begin in mid-FY 1981. We will achieve full operation, with six coils in the toroidal array and pulse-field testing capability, the following fiscal year.

Fission reactor irradiation experiments, to be carried out at the Oak Ridge Reactor (ORR), have been designed and will result in displacement damage and helium production rates accurately simulating the effects of 14-MeV neutrons. In FY 1980, we will begin a three-year experiment that will produce damage levels consistent with ETF and INTOR requirements.

Approval for initiation of the LPTT is expected in FY 1980 or FY 1981; if secured, operation of the LPTT will begin in FY 1984 or FY 1985.

Begun in FY 1979, an initial Generic Environmental Impact Statement for fusion power systems should be completed in FY 1981.

Fission—Breeder (AG 10)

Technical Thrust

The Laboratory's breeder reactor programs will continue to provide base technology and engineering support to national programs. Currently, work is focused on two reactor types—the sodium-cooled breeder and the helium gas-cooled fast breeder.

Sodium-Cooled Breeder (AG 10 20). The enhancement of economics, safety, reliability, and breeding performance will continue as the goal of our development efforts on the liquid-metal (sodium-cooled) fast breeder reactor (LMFBR). The most important programs included in these efforts focus on the following areas: safety, physics, measurements and controls, fuels, high-temperature structural design (HTSD), materials behavior and development, nondestructive testing (NDT), and participation in the International Nuclear Fuel Cycle Evaluation (INFCE) program.

Pending resolution of uncertainties in the national program, particularly the question of whether a larger, so-called development plant based on current conceptual design studies (CDS) should be substituted for the Clinch River Breeder Reactor (CRBR) Plant, the details of ORNL's LMFBR program are somewhat indefinite. However, at the current stage of U.S. development, the base-technology problems and engineering support needs associated with the development of any demonstration-level plant are so similar that we do not anticipate major program changes. The results of INFCE, to be officially reported in February 1980, should not alter this situation.

Our safety program will continue to assess the transient fluid-flow and heat-transfer behavior of sodium-cooled breeder cores under accident conditions. This work will be performed in our Thermal-Hydraulic Out-of-Reactor Safety Facility (THORS), which is a major DOE installation for experiments on sodium heat transfer in electrically simulated breeder reactor fuel assemblies under flow and power transients. In addition, we will continue to develop safety sensitivity methods, to maintain computerized data bases for reliability and safety data, to assess the environmental impact of advanced fuels, and to evaluate models for radioactivity releases. Beginning in FY 1980, the safety program will be managed by the Fast Reactor Safety Technology Management Center at Argonne National Laboratory (ANL).

As before, the physics program will generate nuclear data using the capability provided by the Oak Ridge Electron Linear Accelerator (ORELA), the major U.S. source of data on neutron capture in fissile, fertile, and core structural materials. Furthermore, major efforts will be maintained in shielding analysis and methods development (including multidimensional diffusion and transport analyses as well as cross-section processing and sensitivity

codes). The collection, evaluation, and distribution of shielding codes, processed cross-section libraries, and methodology by our Radiation Shielding Information Center (RSIC) will also continue as an important activity.

In the area of measurements and controls, the Laboratory will retain its prominent roles in thermometry and the development of neutron sensors and surveillance and diagnostic systems. Also, our unique capability in reactor control and protection system design will, as in the past, provide project support.

Our fuels development effort is expected to continue at a reduced level in support of Reprocessing and Fabrication Program objectives. To support the LMFBR fuel-cladding and duct development program, the swelling and phase stability of modified AISI 316 alloys irradiated in the Experimental Breeder Reactor-II (EBR-II) will be further assessed and improved using advanced analytical-transmission electron-microscopy techniques. Beginning in FY 1980, these tasks will be managed by the Reactor Fuels and Materials Technology Management Center (RFMTMC) at Hanford Engineering Development Laboratory (HEDL).

In its HTSD program, the Laboratory will continue to develop new and improved structural design analysis methods and criteria for components operating at temperatures in the creep range. This task includes the development of structural analysis methods, criteria to prevent structural failures, simplified design methods, and confirmatory structural tests. ORNL will make this technology available to component designers by providing design analysis tools, guidelines, codes, and standards.

Materials behavior studies supporting the HTSD effort will, as in the past, include updating national mechanical properties test matrices, generating a broad range of mechanical properties data, and operating a data storage and retrieval system. Materials development studies will include welding and brazing development, alternative methods of fabrication of large-diameter pipe and fittings, and commercialization of high-strength ferritic steels for fast breeder reactor (FBR) circuits.

ORNL will also continue to develop, and to coordinate national development efforts for, advanced NDT methods for the inspection of piping; transition joints, and steam generators both during manufacture and in service.

Because of our achievements in HTSD and materials development, DOE has asked us to establish the Materials and Structures Technology Management Center (MSTMC) for breeder reactor applications. With policy guidance from DOE, the MSTMC will assume technical management of the national program in FY 1980. A more complete description of this endeavor is presented later in this chapter, in the section entitled "Lead Missions for the Assistant Secretary for Energy Technology."

Gas-Cooled Breeder Reactors (AG 10 30). Potentially, the gas-cooled fast breeder reactor (GCFR) will have relatively low capital costs and, using oxide fuels, relatively high breeding ratios compared with other FBRs. During this planning period, the main goal of this subactivity will be the construction and commissioning of the Core Flow Test Loop (CFTL) and the subsequent construction and operational testing of simulated fuel assemblies in the CFTL. The data obtained from testing the heat-transfer, pressure-drop, and thermal-hydraulic as well as structural behavior of simulated GCFR fuel assemblies in the CFTL will provide information on the operating characteristics and performance of these fuel assemblies under design and abnormal conditions. These data are needed to verify codes and models and to support licensing considerations. Also included in this subactivity will be development of design technology for the closures, shielding, and physics of prestressed concrete reactor vessels (PCRVs). Program planning related to the GCFR is carried out with Helium Breeder Associates and the General Atomic Company; cooperation with the Federal Republic of Germany and Switzerland takes place under the U.S./F.R.G./Switzerland Umbrella Agreement covering gas-cooled reactor technology.

Major Changes

As stated previously, we anticipate no major shifts in emphasis in our LMFBR effort once current uncertainties in the national breeder program are resolved. However, some changes may result from the FY 1980 reassessment of base-technology and engineering support priorities by the national technology centers. Also, substitution of a demonstration-plant design developed through the CDS program for the CRBR could significantly alter our programs. Possible changes include (1) greater emphasis on shielding analysis of pool-type reactor designs, (2) reorientation of THORS experiments to accommodate advanced fuels, and (3) initiation of a concentrated effort to qualify an advanced ferritic steel (9 Cr/1 Mo) and obtain ASME Code approval in time to consider its use in the "development plant."

With respect to the GCFR, a final decision is being made on whether to change core flow direction from down to up. This would improve operational characteristics and safety but would necessitate revision of the CFTL design.

Major Issues

More prominent involvement of ORNL technical experts in foreign exchange programs is an essential need of our LMFBR effort. These foreign programs are gaining increasing importance as this country retains the breeder option but continues to fall behind in the development of a viable base to ensure timely acceptance of LMFBRs by utilities.

For GCFR development, experimental verification is needed of effective afterheat removal following a loss-of-coolant accident (LOCA). Also, an international program must be developed enabling cooperation with European efforts.

Fission—Nuclear Power Development (AG 20)

Technical Thrust

The nuclear power development programs at ORNL focus on three important areas—high-temperature gas-cooled reactor (HTGR) technology; fuel cycle technology, both reprocessing and refabrication; and nuclear standards development.

Gas-Cooled Thermal Reactors (AG 20 30). This subactivity will develop and assess base technology pertaining to gas turbine and high-temperature process-heat HTGR systems. The gas turbine HTGR, potentially the lowest-capital-cost converter reactor, has unique siting capabilities, especially when used with dry cooling towers; it also works well in symbiosis with FBRs. The process-heat HTGR has potential application to high-temperature thermochemical processes associated with hydrogen production. The development areas included in this subactivity pertain to HTGR design, operation, and safety. Specifically, work will consist of (1) analysis of fission-product behavior and shielding problems; (2) testing, development, and evaluation of fuels; (3) basic design and model testing of PCRVs; (4) gathering of basic information on materials behavior; (5) study of the irradiation creep of graphite under reactor conditions; and (6) evaluation of alternative reactor designs that may improve fuel utilization and overall economic performance. Planning for the HTGR program is carried out with Gas-Cooled Reactor Associates, General Atomic Company, and General Electric Company; cooperation with the Federal Republic of Germany takes place under the U.S./F.R.G. Umbrella Agreement covering gas-cooled reactor technology.

Consolidated Fuel Reprocessing (AG 20 40). ORNL has been designated by DOE as lead laboratory for fuel reprocessing research and development (R&D). The program focuses on breeder reprocessing R&D, an area in which ORNL has led for many years. However, the new role also includes management of major subprograms concerned with converter and HTGR reprocessing and pyrochemical methods. The goal of the Consolidated Fuel Reprocessing Program (CFRP) is to develop nuclear fuel reprocessing technology that can be applied to commercial-size operations. The program is directed primarily at the reprocessing of uranium-plutonium fuels from FBRs; secondary emphasis is placed on thorium-uranium fuels. All phases of development—from laboratory hot cell investigations to pilot-plant demonstration with fully irradiated fuel—are included.

To provide the necessary testing capabilities, two capital-funded facilities are planned. The Integrated Equipment Test Facility (IET), which will allow integrated testing of equipment and processes with simulated fuel, is now in the Title II design phase. Construction, at a total estimated cost of $16 million, will begin in FY 1979; operation will begin in FY 1982. Testing of equipment and processes with fully irradiated fuel will be provided for by the Hot Experimental Facility (HEF). Although the HEF is now only in the conceptual design phase, the beginning of Title I design is proposed for FY 1981 or FY 1982 and construction for FY 1984. Because it will process irradiated fuel, the HEF will be designed to be an exemplary model with effluent-control, safeguards, waste-management, and fuel-handling systems that meet all regulations for protecting plant personnel, the public, and the environment.

The Laboratory also leads in R&D for fabrication of gel-sphere-pac fuel. The program was inaugurated during the last quarter of FY 1977 and is conducted through funding from both the Reactor Research and Technology Division (RRT) and the Division of Nuclear Power Development (NPD).

Based on the earlier sol-gel concept, technology being developed at ORNL is directed toward remote fabrication of fuel. A primary consideration in the program is the fabrication of proliferation-resistant fuel for light-water reactors (LWRs); however, other

significant objectives are improved fuel performance and fabrication benefits. Remote fabrication of uranium-plutonium oxide fuel for fast reactors is the undertaking of the RRT-funded program. Considerable interest has been shown in this program by Exxon, Westinghouse, Consumers Power Company, and the Tennessee Valley Authority (TVA). Along with gel-sphere-pac fuel, gel spheres can also be used to make pellet fuel, offering the benefit of dust-free feed.

Facility Management and Operations—Power Development (Nuclear Standards) (AG 20 60). The Nuclear Standards Management Center (NSMC) has been established at ORNL (also discussed later in this chapter under "Lead Missions for the Assistant Secretary for Energy Technology"). The center provides technical management of the Nuclear Standards Program for NPD, which has the lead division role for standards activities of the nuclear energy programs funded by Energy Technology—Nuclear (ETN). The key objective of the NSMC is to ensure that information and experience gained in ETN-funded programs are documented in standards suitable for use in future programs and activities in both the public and private sectors. Under the leadership of the center, ORNL's Nuclear Standards Office (NSO) provides technical support staff for the production of standards and operates a standards information center.

Major Changes

In the gas-cooled reactor program, emphasis has changed from the steam cycle to gas turbine concepts; some consideration is also being given to process-heat applications. Despite a slowdown in May 1978, conceptual design of the HEF, which is necessary for the reprocessing program, has resumed its scheduled pace and will be completed in FY 1980. An important new technical thrust in reprocessing, which will seek substantial improvement in proliferation resistance through suitably engineered systems, will begin in FY 1980; this project is described in the following chapter, in the section entitled "New Initiatives for the Assistant Secretary for Energy Technology." Regarding nuclear standards development, a plan for the operation of the NSMC is being developed.

Major Issues

It is important to the gas-cooled reactor program that a clear understanding of the need for the gas turbine and/or process-heat systems be developed and that the support of utilities and industry be obtained. Plans for cooperative work with the Federal Republic of Germany must also be refined. As long as uncertainty in the national LMFBR program continues, our reprocessing plans will remain undefined. However, for the next few years the R&D program (including operation of the IET) should proceed as planned. The major uncertainty—the timing of the pilot-plant demonstration—will be resolved when we receive a firm decision to proceed with a demonstration breeder reactor. Successful demonstration of fuel recycle technology in the HEF must coincide with the LMFBR demonstration. The breeder reactor is the driving force of the CFRP, and the strategies of the two programs must coincide. With regard to refabrication, the relative importance of sphere-pac fuel in the national fuel development plan has not yet been defined.

Commercial and Defense Waste Management (AG 30/JM 05)

Technical Thrust

Work in this program can be divided into two broad categories. That included in the first, in-house waste operations, provides for the management of all radioactive wastes generated at ORNL in its R&D and production programs. Research and development efforts included in the second category, waste technology development, support the resolution of social and technical issues in nuclear waste management.

In-House Waste Operations. This category comprises the activities surrounding the operation of ORNL's radioactive waste treatment systems. The systems included are (1) the low- and intermediate-level liquid waste handling system; (2) the laboratory ventilation system controlling gaseous radioactive waste; (3) the burial grounds used for the receipt, handling, and routine disposal of low-level solid waste; (4) the facilities at which solid waste contaminated with transuranic nuclides is segregated and will be stored until it can eventually be retrieved and disposed of in a geologic isolation facility; and (5) the shale-fracturing facility that processes intermediate-level waste for disposal as a cement grout in the shale formation underlying ORNL. Also included are the necessary supporting activities, such as process development, engineering studies, and conceptual design. This work is funded under Activity JM 05, Defense Waste Management.

The long-term objective of the waste management operations program is to ensure conformance with future regulations by applying new technology and improving facilities. This improvement of ORNL waste management practice will require (1) development of methods for handling stored and newly generated transuranic waste, (2) implementation of programs aimed at reducing the amounts of waste generated, (3) application of technology that will reduce waste volumes, and (4) expanded use of hydrofracture to reduce ORNL's reliance on shallow land burial. Equipment and facility upgrading and replacement, which will further reduce effluents, will continue. Also, methods currently being developed will be used to stabilize wastes in ORNL burial grounds. A comprehensive plan for decontamination and decommissioning of facilities is being prepared and should be available by the end of the second quarter of FY 1980; decontamination and decommissioning will be an increasingly important aspect of ORNL's future effort.

Four waste operations capital projects, which have a combined total estimated cost of about $65 million, are in varying stages of planning or execution: the new Hydrofracture Facility is an FY 1978 project with a total estimated cost of $5.4 million; Intermediate-Level Waste Facilities Modification, an FY 1975 project with a total estimated cost of $14 million; Improvements to Radioactive Waste Facilities, an FY 1981 project with a total estimated cost of $20 million; and the Solid Waste Processing Facility (SWPF), an FY 1982 project with an estimated cost of about $25 million to $28 million. Also, program plans include expenditure of considerable general plant project (GPP) funding for facility improvements. Two important milestones are completion of the burial-ground monitoring system, scheduled for FY 1982, and, for FY 1984, completion of burial-ground corrective measures.

Waste Technology Development. The R&D included in this category focuses principally on alternative waste processes and forms; the tasks are funded under both Activity JM 05, Defense Waste Management, and Activity AG 30, Commercial Waste Management. As associate lead laboratory in the Low-Level Waste Management Program [Idaho National Engineering Laboratory (INEL) is lead laboratory], ORNL participates in formulating program strategy, develops improved methods for shallow land burial and advanced biological treatment methods and analyzes alternative disposal concepts, contributes to systems analysis and criteria development, and will provide for formal information exchange. Beginning in FY 1981 or FY 1982, we will be involved in managing (and, in some cases, demonstrating) the various improved process technologies, the improved shallow land burial techniques, and the disposal methods alternative to shallow land burial. Selection of the first alternative for demonstration is scheduled for FY 1980; commencing of demonstration for sometime during FY 1983 to FY 1985.

Our investigations of alternative waste forms for high-level waste are in various stages of laboratory development. Fixation in specially formed concrete and cermets is being studied, and the use of the sol-gel process is being considered because of its amenability to remote operations. Because at least one of the candidate forms will probably soon be selected for large-scale study, we expect ORNL's program to progress from laboratory development to scale-up and demonstration activities.

In our transuranic waste studies, an important activity is one in which the volume of metal wastes is reduced by melting. Another objective of our waste technology R&D is to develop methods for decreasing the release of radioactive gases in airborne waste. Other tasks in this category provide for the decontamination and decommissioning of radioactively contaminated surplus facilities at ORNL, the development of geologic disposal technology, and the study of radioactive waste transportation.

If current Laboratory proposals for integrating and coordinating waste management analysis are accepted, ORNL will be heavily involved in strategic and tactical analyses that will assist DOE Headquarters and lead field offices in program direction.

Major Changes

The reorganization of the national DOE waste programs on a lead-site basis has required reorganization at ORNL to provide for the effective management of the additional interfaces and the various budgeting, reporting, and cost-accounting requirements. As part of the national reorganization, ORNL has assumed the associate lead role in the Low-Level Waste Management Program, the responsibilities of which are outlined earlier in this section. Emphasis on our in-house waste operations has increased: major improvement projects are proposed, and direct funding, rather than Laboratory overhead, will provide operational support. New areas of attention are transuranic wastes and decontamination and decommissioning. To comply with current directions and regulations of

DOE and other agencies, ORNL is updating its waste management operations plan, giving particular attention to the recommendations of the IRG Report.[1] ORNL's comprehensive plan, to be completed at the end of the third quarter of FY 1980, will delineate project and program requirements for FY 1983 and beyond. The Laboratory is becoming more involved in process R&D of alternative methods for fixation of high-level waste. We anticipate growth in our waste systems analysis work and expanded application of our information center capabilities for data acquisition and organization of a data base.

Major Issues

Inadequate funding has limited our ability to evaluate some potentially desirable technologies, including technologies for gaseous wastes, alternatives for high-level waste, and alternatives to shallow land burial.

Management responsibility for the national program in nuclear waste is divided among seven lead laboratories and five DOE operations offices. This requires that ORNL staff make the effort to interface effectively and to adjust to varying management styles and reporting requirements.

More specifically, ORNL faces several potential problems in radioactive waste management. One is a need for additional space. At current waste generation rates, and assuming that changes in shallow land burial regulations do not shorten its remaining lifetime, Solid Waste Storage Area 6 will be filled in about 7 years. Initial work in identifying potential sites was completed at the end of FY 1979. About two years of geohydrological study are now needed to determine a suitable site; after selection, the site will then have to be prepared for burial operations. It is hoped that an acceptable site can be readied for operations by the end of FY 1985.

In addition, the area currently used for retrievable storage of transuranic wastes will, if current generation rates continue, be filled in about ten years. Although facilities under construction will provide storage space for an additional five years, a new storage area and new facilities will have to be established by FY 1990.

The current target date for operation of the Waste Isolation Pilot Plant (WIPP), where we expect to send our stored transuranic wastes, is FY 1988. The currently proposed acceptance criteria for wastes sent to the WIPP would require that most of ORNL's stored wastes be sorted and repackaged. Although these criteria are only tentative, their acceptance might necessitate construction of a new waste-packaging facility for operation by FY 1990.

Increased monitoring capability is another need. Regulations proposed by the Environmental Protection Agency (EPA) under the Resource Conservation and Recovery Act (RCRA) will require extensive monitoring of groundwater at solid waste disposal areas. Work is currently in progress to develop hydrological models of our burial areas, and by the end of FY 1983, an acceptable monitoring system should be completed.

Fission—Advanced Systems (AG 40)

Technical Thrust

Included in this activity are several diverse areas of work. In the area of Space and Terrestrial Systems, ORNL is providing materials R&D supporting the development of isotope power sources for use in space missions and is developing the use of by-product radionuclides for conservation applications. The Laboratory is also playing a major role in the Alternative Fuel Cycle Evaluations Program (AFCEP) by providing assistance to the Nonproliferation Alternative Systems Assessment Program (NASAP) and contributing to U.S. participation in the INFCE program. This assistance includes evaluation of the proliferation- and diversion-resistant features of various fuels and fuel cycles and economic assessment of associated fuel cycle facilities. Also involved is the preparation and critical review of documents for submission to INFCE working groups.

Space and Terrestrial Systems (AG 40 20). The Laboratory's role in this subactivity includes characterizing, evaluating, and developing new and improved materials for use in current and future space missions and in terrestrial applications. Activities directly supportive of U.S. space programs continue to focus on developing materials for the isotope fuel cladding and the thermoelectric-conversion system to be used in the 1981 Galileo and 1983 Solar-Polar space missions. Flight systems development for these missions has been redirected from high-efficiency selenide thermoelectrics, which are not technologically ready, to the silicon-

[1]Interagency Review Group on Nuclear Waste Management, *Report to the President on Nuclear Waste Management*, TID-29442, Washington, D.C., March 1979.

germanium thermoelectrics used previously. As a result, we have decreased our materials support for the selenide system and initiated new tasks in support of the silicon-germanium system. However, to assist the 3M Company in its development of the selenide thermoelectric technology for application to possible future missions, we shall continue to provide the materials necessary to that system.

Having developed an improved iridium alloy for the general-purpose heat source to be used for the FY 1983 space mission, we are now fabricating this alloy for flight systems hardware. Because of the lower efficiency of silicon-germanium thermoelectrics as compared with the selenide thermoelectrics, more fuel capsules will be required than were originally planned and fabrication work will not be completed until FY 1981. ORNL will also retain responsibility for refining and supplying iridium.

A small effort included in the flight systems technology program, which is aimed at improving the reliability of welds in the dynamic isotope power system, will be maintained at the same level through FY 1981.

Through the terrestrial isotope applications project, we will continue to provide the materials technology required for future systems development. The curium recovery and compatibility work was completed in FY 1979, and work on the compatibility of strontium fluoride should be completed in FY 1981. The Laboratory will also continue to support the sewage sludge sterilization program through the development and characterization of insoluble radioactive cesium compounds.

Advanced Systems Evaluations (Nuclear Energy Assessments) (AG 40 30). Nuclear energy assessment tasks include economic, technical, and environmental assessments of the ability of nuclear power plants and their alternatives to supply electricity and heat. Specific efforts in this activity, for which ORNL is a lead laboratory, include cogeneration activities and energy center studies. Currently, we are initiating a major district heating study for, and in cooperation with, St. Paul, Minnesota. Sites in South Carolina and Utah are being evaluated as future locations for nuclear energy centers, and the atmospheric impact of heat release from the Bowen plant in Georgia is being measured to support predictions of energy center heat releases. A large commitment of resources was made to NASAP in FY 1979, but this work will be phased out in FY 1980. A significant number of studies and assessments are carried out through R&D subcontracts.

Major Changes

As described above, the shift in flight systems development from selenide thermoelectrics to silicon-germanium technology will reduce our effort in FY 1980 and FY 1981. In addition, responsibility for decommissioning and decontamination of the ^{244}Cu facility has been transferred to Activity JM 05, Defense Waste Management, for FY 1980. The Space and Terrestrial Systems Branch of DOE's Advanced Nuclear Systems and Projects Division (ANSP), however, has requested that we provide the lead role in developing materials technology and coordinating systems contractors on current and future missions. Additional funds will be provided for this endeavor.

We expect to use the staff released by the sharp decrease in nuclear assessments in FY 1980 in emerging assessment areas such as fossil energy and conservation.

Major Issues

In the Space and Terrestrial Systems program, planning beyond FY 1981 is difficult because there are no approved new space missions beyond FY 1983. Although several potential missions are being considered, decisions on these are not expected until late FY 1980.

Fossil Energy

Technical Thrust

In the next several years, we expect an expansion of the Laboratory's broad fossil energy program. In addition to work funded by the DOE Fossil Energy Program and TVA, this program includes closely related fossil energy efforts funded by the Assistant Secretary for the Environment and the Office of Energy Research (OER). Currently, the total support related to fossil energy constitutes almost 10% of the overall Laboratory operating budget.

The main thrusts of experimental R&D for the DOE Fossil Energy Program are in coal liquefaction, fluidized-bed combustion, magnetic coal beneficiation, and materials and component development and testing. Other important R&D projects included in the ORNL program consider environmental control technology, solid waste disposal, and tertiary oil recovery. Engineering studies, program planning, and environmental assessment in support of fossil energy will continue to be important activities. ORNL support of the programs managed by the Energy Technology Centers (ETCs) and of pilot

and demonstration projects [Solvent Refined Coal-I and -II (SRC-I and -II), H-Coal, and Exxon Donor Solvent] is expected to increase.

New directions for the fossil program include expanded roles in materials, instrumentation and controls (I&C) development for automation of coal cleaning plants, and R&D associated with flue gas cleanup.

In addition to the work being performed for DOE's fossil programs, a strong program in coal chemistry is carried out through the Office of Basic Energy Sciences (OBES), in which the Laboratory continues to have the leading role in investigating the health and environmental effects of fossil energy use, particularly coal conversion. ORNL is also providing, via TVA funding, direct support to TVA's demonstrations of fluidized-bed combustion (10-MW pilot plant and 200-MW demonstration plant) and coal cleanup.

Mining Research and Development (AA 10). Our work in this activity will concentrate on (1) the evaluation, development, and commercialization of magnetic beneficiation of dry, pulverized coal, including both high- and open-gradient methods and (2) a new initiative aimed at the automation of conventional coal cleaning plants (discussed in the following chapter under "New Initiatives for the Assistant Secretary for Energy Technology"). The program on automation of conventional coal cleaning plants, in which ORNL has been given lead responsibility by the DOE Pittsburgh Mining Operations Center, includes (1) assessing currently used I&C, (2) developing measurement instruments and control systems for specific operations, and (3) developing design information for full automation of plants. As planned, this will be a five-year program culminating in the design and demonstration, under field operating conditions, of improved I&C systems. Cooperative programs in coal cleaning are being discussed with both TVA and the Electric Power Research Institute (EPRI), and funding from these organizations is anticipated.

Coal Liquefaction (AA 20). Our experimental and analytical work in this activity includes both studies that generically support the technology and studies applicable to specific processes and projects. Experimental work consists of exploratory chemical and chemical engineering research, applied R&D to establish a technology data base, R&D of unit processes and operations, development of instruments and components, and assessment and development of technology for treating and disposing of waste streams. Analytical studies comprise technical and economic evaluations; computerized design, modeling, and cost estimation; technical support services; and assessment of environmental aspects. Specifically, the tasks include (1) development of an improved understanding of the chemical and physical structure of coal, (2) exploratory investigations of advanced liquefaction techniques, (3) determination of the physical properties of coal liquids and coal-oil slurries under process conditions, (4) process evaluation and review of processes, (5) development and testing of portable monitors for detecting low levels of polynuclear aromatic hydrocarbons, (6) assessments related to the environmental aspects of liquefaction, (7) technical support provided to the SRC demonstration and H-Coal pilot-plant projects, and (8) measurement and correlation of vapor-liquid equilibrium data for coal-derived liquids.

Because of the apparent imbalance between the analytical efforts and the experimental R&D, we believe both increased funding and continuity are needed for our experimental programs—especially for applied chemistry and chemical engineering support of coal liquefaction. In particular, work on physical properties measurements of coal liquids and slurries of coal in coal-derived liquids should be expanded, as should work on the measurement and correlation of rheological data from the slurry preheaters operated at ORNL and in the various pilot plants. We also plan to build and operate equipment for measuring vapor-liquid equilibrium data for coal-derived liquids; testing of selected critical components will be coordinated with ongoing programs at the ETCs.

The time frame for much of the liquefaction work will be determined by the design and operating periods for the pilot and demonstration plants. The H-Coal and Exxon Donor Solvent pilot plants will begin operation soon, in FY 1980; however, the SRC-I and -II demonstration plants are not expected to be operational until FY 1984.

Surface Coal Gasification (AA 30). Work in this area focuses principally on processes that are at an early stage of pilot-plant operation or demonstration-plant design and planning. Continuing efforts include (1) performing engineering evaluations of processes and specific gasifiers, (2) developing improved process modeling capabilities, (3) identifying and testing critical components required for pilot and demonstration plants, and (4) reviewing demonstration-plant designs, environmental assessments, and generic studies related to gas cleanup and

purification. We will also provide strong support to the ETCs through the development and testing of components of the critical equipment used in coal preparation and handling facilities.

Advanced Power Systems (AA 40). District heating by means of cogeneration is one method for increasing the efficiency of primary energy use in the United States. ORNL is providing technical management for a cooperative evaluation of coal cogeneration power plants for a district heating system for the Minneapolis–St. Paul area; the project is partially funded by Northern States Power Company.

Work in this activity is also conducted using program development funds provided for developing new research ideas relating to advanced power systems. Future effort will include the analysis, assessment, and development of advanced power systems; the study of fuel cell chemistry and materials will be important in this effort.

Direct Combustion (AA 50). Our direct combustion work is concerned principally with researching and developing atmospheric fluidized-bed combustors (AFBCs) that will burn coal in an environmentally acceptable manner in both utility and industry applications. Our main activities will involve four areas: (1) work on the atmospheric fluidized-bed coal combustor for cogeneration, (2) support for TVA's AFBC demonstration program, (3) support for the AFBC program at the Morgantown Energy Technology Center (METC), and (4) a new initiative (discussed in the following chapter under "New Initiatives for the Assistant Secretary for Energy Technology") that deals with the supercharged fluidized-bed combustor (SCFBC).

Work on the coal combustor for cogeneration will include designing, constructing, and operating a 1.5-MW AFBC test system. Successful demonstration of this system is necessary to the development of an industrial cogeneration system capable of supplying electric power and process heat simultaneously. Design of the AFBC test system will be conducted during FY 1980 and FY 1981, and construction and operation will follow. During FY 1983 to FY 1985, industry participation will be employed in demonstrating the technology. Support of the TVA program will include experimental work in materials and components, evaluations and technical assistance, and review of the AFBC demonstration plant environmental impact statement. Our participation in the METC program will probably emphasize materials and coal-feeding R&D. The Boiler Materials Test Apparatus (BMTA), which will be constructed during FY 1980, will allow materials testing under fluidized-bed combustion conditions.

Advanced Research and Development (AA 60). Work in this activity will center on our substantial, and growing, materials development and testing program. In addition to assuming the lead laboratory role for managing the fossil energy materials program, ORNL will undertake in-house R&D in the following areas: (1) the development of advanced materials for fossil energy systems, (2) failure prevention and analysis in pilot and demonstration plants, and (3) the study of corrosion and erosion mechanisms in coal conversion plants.

Other advanced research and technology support will include (1) investigation of the potential for application of ceramic recuperators as well as the technology required for their implementation; (2) expanded studies of the physical and chemical structure of coal and of coal conversion chemistry; (3) systems analysis support in the areas of environmental assessment, engineering studies, program planning, and performance assurance; (4) development of innovative techniques for removal of solids from liquids; and (5) initiation of a new project for measuring and correlating vapor-liquid equilibrium data for coal-derived liquids. To achieve the improved understandings of materials, liquefaction process technology, and coal liquefaction chemistry sought in this activity, work must be conducted during FY 1980 to FY 1986 when the liquefaction pilot plants and demonstration plants will be in operation.

In Situ Coal Gasification (AA 80). In this activity, we are developing engineering data to support the design and interpretation of field experiments on underground coal gasification (UCG). Work includes (1) pyrolyzing large blocks of coal and characterizing pyrolysis yields and mechanisms, (2) measuring physical properties of coal and char, and (3) characterizing pyrolytic and physical properties of overburden from UCG sites; it is conducted in conjunction with field tests and demonstrations being performed by industry and DOE. Because of substantial decreases in the FY 1980 national budget for in situ coal gasification, the future of the activity is uncertain.

Enhanced Oil Recovery (AB 10). This R&D activity includes research on producing, from industrial waste streams, chemicals used for micellar flooding; identifying elements and ions that can be used as tracers; and evaluating the ion-exchange characteristics of chemicals used in enhanced oil

recovery. We will place increased emphasis on relating our work to field-test information.

Major Changes

Two principal program changes are anticipated in the near term. One is a major expansion of our materials-related work; the second, increased involvement in experimental chemical engineering efforts related to developing environmental control technology and characterizing coal-derived liquids and oil-coal slurries under liquefaction process conditions. Also expected is an increase in activities in two new initiative areas—flue gas cleanup and SCFBC development. In the long term, we foresee significant growth in work on coal chemistry and solid waste disposal.

Increased funding and more continuity are necessary in our experimental R&D activities related to coal liquefaction, particularly in applied chemistry and chemical engineering. This change is needed to build and maintain the expertise with which we provide technical support to the major liquefaction projects managed by DOE's Oak Ridge Operations Office (ORO). Also, the liquefaction R&D activities provide important support for the entire fossil energy program.

New facilities will be required to enable work on vapor-liquid equilibria for coal-derived liquids as well as to provide a growing capability to support the liquefaction and fluidized-bed combustion programs. These facilities include the Energy Systems Research Laboratory (ESRL), the BMTA, and a number of special-purpose test facilities.

We anticipate increasing interaction with organizations involved in demonstration projects, including TVA, EPRI, Gulf, and Southern Company Services.

The fossil energy program should have one of the highest growth rates at the Laboratory during this planning period: the internal operating level will double, and our responsibilities in managing major programs will involve us in larger amounts of subcontracting.

Major Issues

As a new and growing effort at the Laboratory, the fossil energy program has significant needs for equipment and facilities. To supply these needs, a substantial increase in capital equipment funds is required over the next several years. (Facility needs are addressed in the chapter entitled "Site and Facilities Development.") During this planning period, we shall provide substantial assistance to the ETCs as they take on increased management responsibilities; however, these relationships have not yet been defined. We must also establish and maintain a viable and stable experimental R&D program in coal liquefaction with particular reference to applied chemistry and chemical engineering.

Major Results or Milestones

Advances in coal liquefaction technology are expected in specific areas of research. One of these is coal-slurry preheating, in which exploration of rheological and thermal characteristics will continue through FY 1980. New methods of liquefying coal will be investigated: work scheduled for FY 1980 includes evaluating the use of phenol for redistributing hydrogen within coal. The physical properties of coal liquids will be determined at temperatures and pressures representative of coal liquefaction processes. During FY 1979, we measured viscosity and density; during FY 1980, we will measure heat capacity and thermal conductivity.

Beginning in FY 1980, the Laboratory will have lead responsibility in assessing and developing I&C for conventional coal cleaning plants; this work will continue as a substantial effort for several years. Development of magnetic beneficiation of coal is expected to progress, with significant industry interaction, through the pilot-plant and demonstration stages. Work on environmental impact statements for the various fossil energy demonstration plants has been initiated, and completion of these statements, in draft form, is expected during FY 1980.

Construction of the BMTA, which will facilitate testing of materials under fluidized-bed combustion conditions, will also be completed during FY 1980.

Experimental laboratory and bench-scale programs in support of coal gasification should result in new techniques for recovering nonrenewable commodities and catalysts for gasifier ash. During FY 1980, we expect to demonstrate the use of continuous-processing equipment.

A 1.5-MW(t) test unit of the atmospheric fluidized-bed coal combustor for cogeneration will be designed during FY 1980 and built during FY 1981. Following a 6000-hr endurance test of the combustor, the gas turbine will be installed for testing in both open- and closed-cycle modes. After FY 1981, as the technology

is applied under commercial conditions, our work will focus on providing R&D support to demonstration activities.

A predictive model describing the behavior and transport, under landfill disposal conditions, of the constituents, including trace metals, of residues from coal conversion and use will be developed in conjunction with demonstration-plant projects. We are also developing a new program for reliability assessment of planned coal conversion plants; it is based on methodology used at the Oak Ridge Gaseous Diffusion Plant (ORGDP) for reliability analysis.

Conservation

Conservation work for DOE is sponsored by both Energy Technology (ET) and Conservation and Solar Applications (CS). This section discusses work conducted and managed by ORNL for ET. Growth in ORNL's conservation program during this planning period will result principally from increased funding for ongoing activities and will be managed through additional subcontracting. After FY 1981, there will be little increase in internal effort.

Technical Thrust

In the study of electric utilities systems, ORNL has undertaken programmatic responsibilities for developing technologies for electrical use management. We are also systematically examining gaseous insulators for possible use in very high voltage transmission systems, and we are analyzing the performance and reliability of operating power plants. Our work in energy storage focuses on the development of advanced materials and systems for low-temperature thermal storage.

Utilities (C1). In cooperation with two utilities, we are field testing two-way communications systems; such systems will enable utilities to implement time-of-day meter reading and to increase operational efficiency by controlling loads. ORNL is also participating in use-management demonstration projects with eight utility companies in various parts of the country. In these demonstrations, homes will be equipped with hot or cold thermal storage equipment and with instrumentation enabling the utility to control the times at which electricity is used. A distributor on the TVA system is being selected to participate in a more extensive demonstration of use management and of automated operation of the distribution network. It is hoped that these technologies will provide means for modifying our patterns of electricity generation so that, through improved system efficiencies, we can reduce our use of scarce fuels. The automated distribution network will improve the reliability of electric energy delivery, and its demonstration will test the effects of introducing dispersed generation into utility service. In the future, use-management research will emphasize the development of assessment methodology rather than demonstrations. As load management becomes an accepted utility activity, integration of these dispersed technologies will become the program goal.

The Laboratory's program in high-voltage research is providing a more thorough understanding of the physics of gaseous and liquid insulators. We have already identified several compounds and mixtures of compounds that have better insulating properties than does SF_6. Work is being started that will identify and evaluate the possible environmental effects of dielectric insulators.

We are also collecting and analyzing power plant performance data to provide reliability forecasts for plants of various sizes and types.

Multisector (C8). In this activity, advanced thermal storage technologies will be developed and demonstrated for solar energy applications and also for load-management strategies. Included in the program will be a substantial amount of subcontracted research, development, and demonstration (RD&D) as well as in-house experimental and assessment activities. As in previous years, considerable emphasis will be given to the potential use of phase-change materials as compact, economical storage media.

A model is being developed to predict the behavior of metal-hydride beds in hydrogen storage applications. The model, which is based on known physical properties of the materials, is being checked against hydriding and dehydriding experiments and should provide firm support for the design of storage systems. We will continue this work through experiments on various metal hydrides; the experiments will include measurements of properties as a function of bed size.

As a new initiative (discussed in the following chapter under "New Initiatives for the Assistant Secretary for Energy Technology"), we will investigate the thermodynamic and heat-transfer aspects of low-temperature heat utilization with the goal of improving methods of waste heat utilization. An

ongoing activity will support this effort by providing experimental measurements and theoretical interpretation of the physicochemical behavior of molten carbonate fuel cell electrolytes and their interactions with other cell materials.

Major Changes

At the request of the Division of Energy Storage Systems, ORNL's role in low-temperature thermal energy storage has been redefined. We have been asked to accept increased responsibility for diurnal storage RD&D; consequently, aquifer storage work previously performed by ORNL is being reassigned. The diurnal storage developments will be used in solar applications and for load management.

Major Results or Milestones

The tests of two-way communications systems now under way are scheduled for completion in July 1980. In FY 1981, the utility end-use-management demonstrations will be completed and end-use-management equipment will be installed on the selected TVA distribution system.

Solar and Biomass

Technical Thrust

The Laboratory has a modest solar energy program, much of which has been undertaken at the request of DOE. In FY 1979, this program represented less than $1^1/_2$% of the Laboratory budget, and it is not expected to exceed 2% in future years. Expansion of the program will be in in-house R&D and not in management or extramural research. Program funding is supplied by ET and CS; this section discusses the work sponsored by ET, which represents about 80% of the total.

ORNL is actively involved in evaluating the environmental effects of producing and harvesting woody biomass agricultural residues. In consultation with the Solar Energy Research Institute (SERI), we are developing program plans for the study of biomass conversion. We hope to be able to apply our experience with coal conversion technology to this study and are especially interested in conversion systems that utilize advanced bioreactors. Under the Solar Energy Program, a modest photovoltaic program is proposed in which we will evaluate the laser-annealing developments and other advances made in the OBES program; some activity will also continue in the exploration of high-temperature applications for solar energy. ORNL efforts in the heat-exchange and power-cycle activities supporting Ocean Thermal Energy Conversion (OTEC) will be maintained; the open-cycle work will be transferred to SERI (Golden, Colorado) as conditions there permit. However, testing as well as support of SERI by ORNL will be needed for the open-cycle effort. Expansion of experimental work in biomass conversion and photovoltaic research will be given priority over technical monitoring and contract management activities.

Technology Support and Utilization (AD 02). Laboratory resources for performing environmental assessments are being drawn from to carry out the environmental assessment necessary for the biomass program. In addition, we are conducting two projects on whole-tree harvesting and crop-residue removal in collaboration with the Department of Agriculture, the Forest Service, and several universities. The purpose of these projects is to evaluate the impacts of biomass removal on nutrient depletion and erosion in four major U.S. regions. In addition to assuming the lead in setting objectives, developing research plans, and enlisting collaborators, we shall conduct site research at ORNL. The Laboratory will also play a key role in the synthesis and evaluation of data from the ten research sites and will direct the development of environmental control measures necessary to mitigate any potential problems that are identified.

Our assessment program for decentralized solar energy technology examines the social, economic, political, and institutional impacts of decentralized solar energy. This study should assist communities and DOE in evaluating solar energy policy alternatives.

In cooperation with SERI, we are developing plans for a fundamental study of the biophotolysis of water for the production of hydrogen.

Solar Electric Applications (AD 03). ORNL is evaluating fuel and heavy chemical manufacturing processes that require large quantities of high-temperature energy as candidates for a DOE development program on concentrated solar energy. Additional support is being provided to DOE in mission analysis of solar total energy systems and through technical advice and evaluation of equipment and services for the photovoltaic demonstration projects at Mississippi County Community College at Blytheville, Arkansas, and Northwest Mississippi Junior College at Senatobia, Mississippi.

In support of the OTEC program, ORNL is performing experimental and analytical work on advanced heat exchangers, providing technical assistance for heat exchanger development by evaluation of proposals, monitoring contract work, and participating in special committees and conferences. In the development of alternative OTEC power-generating cycles, we are responsible for managing existing subcontracted work and for conducting related R&D work at ORNL on the deaeration program. In FY 1981, we expect a shift in management of the alternative cycle program to SERI, although technical work in this area will continue at ORNL.

Fuels and Biomass (AJ 01). ORNL is assisting DOE with the monitoring of 24 contracts in the Woody Biomass Program covering species screening, stand establishment, improved management strategies, and improved methods of collection and transportation. The Laboratory is evaluating contractor results in terms of extending local data to regional areas.

A program is planned for investigating the use of packed-bed anaerobic bioreactors to produce methane from algae-rich water. In another study of methods for energy recovery from biomass, we will examine pyrolysis of biomass in a hydrogen atmosphere. A related activity, an investigation of possibilities for producing solvents and chemical feedstocks from biomass resources, is also planned. ORNL's work in coal conversion should contribute significantly to these activities.

Major Results or Milestones

During FY 1980, we hope to achieve several important milestones. The final report on Phase I of our decentralized solar technology assessment, which will make a comparison of the potential for solar applications in three different communities, will be completed. We will also finish a cost handbook for solar total energy and a comparison of diesel, gas fuel cell, and solar systems for residential power, both of which will contribute to the mission analysis for small solar thermal power systems.

In this same year, a chemical process and an industrial participant will be selected for a demonstration of high-temperature application of solar energy, and in the OTEC program, the optimization of tilted smooth tubes and of the surface configuration of fluted tubes will be completed. Activities in the whole-tree harvesting program will include installation of monitoring devices on ten experimental watersheds and initiation of data collection.

Geothermal Technology Development (AE 30)

Technical Thrust

In the development of geothermal energy, our efforts are limited to areas in which we have applicable skills and experience. Our program includes activities in engineering R&D and in environmental control and institutional studies.

Currently, we are researching heat-transfer and power-conversion systems. The low-temperature heat-transfer work is expanding and will include continued heat exchanger development. We hope to advance soon to scale-up and field demonstration of enhanced heat-transfer technologies developed at the Laboratory. Also in progress are experimental and analytical studies of heat rejection systems as they relate to geothermal power plants and the direct use of geothermal heat.

Work in the Environmental Assessments Project is focusing on environmental assessments and statements for specific programs and facilities, some of which are associated with the federal Geothermal Loan Guarantee Program. This effort will require subcontracting to industry and consulting firms, for which ORNL will provide supervision.

Major Changes

The heat exchanger development work described above is expected to involve ORNL in the management of subcontracts for the study of waste heat rejection. Because interest in the low-temperature resources of the Eastern Hydrothermal Region will probably increase, our program on low-temperature heat utilization should also expand. We hope to apply our expertise in low-temperature waste heat use, which includes OTEC heat-transfer developments and applied experience with heat pumps, to develop these resources for direct heat applications.

Major Results or Milestones

In the low-temperature exchanger development work, a condenser tube bundle was field tested at the East Mesa Test Facility and will be tested at the Raft River Pilot Plant during FY 1980. Construction of a

500-kW(e) demonstration plant, for which ORNL will supply the test condenser, will be undertaken during FY 1980. In the later years of this planning period, our activities will be aimed increasingly at the utilization of the lower-temperature resources of the Eastern Hydrothermal Region.

The Environmental Assessments Project has a series of milestones for the completion of generic and site-specific assessments.

Lead Missions for the Assistant Secretary for Energy Technology

Consolidated Fuel Reprocessing Program (current role). In prior years, four DOE programs addressed the development of technology for reprocessing specific reactor fuels. At the beginning of FY 1979, however, DOE unified these efforts in one program—the Consolidated Fuel Reprocessing Program (CFRP)—and designated ORNL as the lead laboratory for this mission.[2] The new program, like the earlier ones, focuses on the breeder reprocessing effort. Certain activities directed toward specific fuel cycles, such as the high-temperature gas-cooled reactor (HTGR) at General Atomic, are continuing, but much of the effort is being directed toward problems applicable to many cycles. The Savannah River Laboratory (SRL) not only plays a major role in certain tasks associated with uranium-plutonium cycles in converter and breeder reprocessing, but it also serves as the center for hot-cell flowsheet studies of thorium cycles. The Argonne National Laboratory (ANL) pyrometallurgical program, begun in 1978, has continued and has experienced only minor impact from the consolidation.

ORNL is responsible for technical management of the R&D programs associated with this mission and has established a management system within the same management plan previously used for the ORNL Advanced Fuel Recycle Program. Slightly less than one-half of the technical R&D is done at this laboratory.

ORO is responsible for field office management of the program, which includes providing specific guidance to program participants. After reviewing the program plan, ORO makes recommendations to the Division of Nuclear Power Development (NPD). In addition, it develops, recommends, and justifies budgets to be considered by DOE Headquarters; manages the program to achieve objectives on schedule and within allocated budget ceilings; and coordinates administrative and technical matters with other field offices.

Program support comes not only from ORO but also from subcontractors: numerous subcontractors carry out major portions of the program. About 35% of the work is handled through other national laboratories or major DOE contractors, and another 20% is handled through subcontracts with industrial organizations.

The program is expected to derive additional support through its coordination with similar efforts and through technology transfer. In FY 1979, the program maintained some technical coordination with two programs—the design integration studies that were performed at SRL and that examined the coprocessing option for recycling light-water reactor (LWR) fuel, and the studies examining options for the Barnwell facility, which were performed by Allied General Nuclear Services and managed by the Savannah River Operations Office (SRO). In addition, there will be close cooperation and involvement with the reprocessing industry through an advisory committee of experts in the field. Minor involvement with universities will occur through subcontracts, but essentially no contact with state or local governments will occur.

The reduction in the program's FY 1980 budget projected in Appendix B (Table B.3) is unlikely to happen; this is because we expect to acquire additional funds as a result of current congressional actions. Should significant reductions occur, they will be associated principally with the peripheral R&D thrusts—pyroreprocessing, HTGR reprocessing, and converter reprocessing. We expect our work focusing on the Hot Experimental Facility (HEF) and breeder reprocessing to remain essentially stable in the near term.

Nuclear Standards Management Center (current role). The Nuclear Standards Management Center (NSMC) consists of an Office of Advanced Planning and Implementation (OAPI), the existing Nuclear Standards Office (NSO), and a Nuclear Standards Program Information Center (NSPIC) located within the NSO. The OAPI is primarily responsible for outreach and long-range planning activities relative to expanding the Nuclear Standards Program to cover each of the Energy Technology—Nuclear (ETN) programs and activities. The NSO continues

[2]Letter from J. A. Lenhard, DOE Oak Ridge Operations Office (ORO), to H. Postma, ORNL, Subject: Establishment of ORNL Technical Lead Technology Laboratory for Consolidated Fuel Recycle Program—Reprocessing, Oct. 31, 1978.

to be the executive arm of the NSMC. In addition to its long-standing responsibilities of maintaining the Research Reactor and Technology Division (RRT) standards program, the NSO is now responsible for the formulation and maintenance of other ETN program standards, for developing and operating the NSPIC, and for the provision of assistance to the OAPI outreach and program extension activities. These broadened responsibilities are the basis for the projected growth of the nuclear standards activity (AG 20 60 40) until FY 1982.

The NSMC has a number of critical objectives. These include (1) collecting standards information and providing outreach to program managers; (2) acting as a liaison with national consensus standards organizations; (3) fostering the development and application of program standards; (4) operating the NSPIC; and (5) interfacing with related organizations associated with nuclear standards. Furthermore, the NSMC assists DOE in the evaluation and supervision of nuclear standards activities; maintains, distributes, coordinates, and catalogs ETN program standards; maintains a working group on standards; and provides a long-range coordinating role for ETN- and DOE-wide standards development and application. The Laboratory will ensure coordination between this effort and all ETN programs and activities, except the Naval Reactors Program.

ORNL provides technical management of the Nuclear Standards Program for NPD, which has the lead division role for ETN standards activities. The specific responsibilities of NPD, ORO, and ORNL are spelled out in a management agreement among the three parties.[3] ORNL has played a lead role in nuclear standards—through the NSO—for several years. The NSMC, however, reflects a broadened responsibility and is intended to support the policies and practices set forth in a DOE standards policy memorandum.[4]

ORO provides the Laboratory with implementation-level policy, strategy, and programmatic direction in accordance with approved plans, schedules, and costs. Additional support provided by ORO includes assistance in the development of the national management plan and the national program plan, program guidance to other participating field units, technical staff input to the program, and full services support in all business management areas. ORO also directs ORNL's performance in executing technical and financial aspects of the program and makes recommendations to DOE Headquarters on corrective changes in management, program scope, and funding.

By their nature, standards are a primary means of technology transfer. In addition, all Nuclear Standards Program participants, including DOE, ORO, other related technology centers, and the U.S. industrial community, will be kept informed, as appropriate, through consolidated summary reports, newsletters, quarterly management cost and milestone reports, and annual reports.

This program is covered by Field Task Proposal/Agreement No. 0H022. Applicable budget and personnel considerations are contained in Appendix B, Table B.3.

Materials and Structures Technology Management Center (current role). The objective of the Materials and Structures Technology Management Center (MSTMC) is to manage the national program aimed at developing the structural design and associated materials technologies required for liquid-metal fast breeder reactors (LMFBRs). Technical activities of this lead mission, which DOE has approved,[5] include developing structural design analysis methods and failure criteria and conducting confirmatory structural and related materials behavior and properties tests. In support of these activities, manufacturing and in-service nondestructive evaluation (NDE) techniques are developed to ensure component reliability for demonstration and commercial plants.

Milestones for this mission involve structural design methodology development, materials technology development backup, and NDE development. During the period represented in the summary table for this mission, activities in these areas will continually provide designers of demonstration and commercial plants with the technologies required for LMFBRs. This program will also provide refinements to these technologies as required.

The Laboratory is currently a leader in research related to structural design methods, materials

[3]Letter from R. D. Thorne, DOE Energy Technology (ET), to R. J. Hart, DOE—ORO, Subject: Management Agreement, Nuclear Standards Office, ORNL, Sept. 27, 1978.

[4]Letter from G. W. Cunningham, DOE/ETN, to H. E. Rosser et al., DOE—ORO, Subject: Standards Policy for Nuclear Energy Programs, July 31, 1978.

[5]Letter from J. A. Lenhard, DOE—ORO, to H. Postma, ORNL, Subject: Structural Materials Engineering Technology Center: Lead Laboratory Assignment, Feb. 28, 1979.

properties, and NDE; its in-house programs provide expertise for management of these technology areas. To fulfill the Laboratory's role in this mission, the MSTMC prepares the national program plan with the understanding and agreement of DOE, ORO, and managers of participating laboratories. It also coordinates key milestones with other DOE technology centers and projects. ORNL receives support from DOE, which provides policy, guidance, resources, and overall direction for program planning and implementation. In addition to approving program plans, including the scope, tasks, priorities, major deliverables, milestones, schedules, and costs, DOE retains final accountability for this assignment.

ORO provides ORNL with implementation-level policy, strategy, and programmatic direction in accordance with approved plans, schedules, and costs. Its other responsibilities include (1) assisting in the development of both the national management plan, which defines organizational interfaces and describes the mechanics of management functions, and the national program plan, which identifies the technical work to be done, the timetable, and the participants; (2) providing program guidance to other participating field units; and (3) directing ORNL's performance in executing technical and financial aspects of the program. It also makes recommendations to DOE Headquarters on corrective changes in management, program scope, and funding and provides technical staff input to the program and full services support in all business management areas.

MSTMC contractor participants include (1) DOE laboratories—ANL, Hanford Engineering Development Laboratory (HEDL), Idaho National Engineering Laboratory (INEL), ORNL, and the Energy Technology Engineering Center (ETEC); (2) the Naval Research Laboratory (NRL); and (3) industrial contractors directly funded by DOE—General Electric (GE), Rockwell International (RI), Agbabian Associates, and Westinghouse Advanced Reactors Division (W-ARD). These organizations perform or subcontract fractions of the programs as appropriate: the ratio of work they perform in house to work they subcontract approximates 10:1. The ORNL in-house portion of the national program managed by the MSTMC is about 38% (as the summary table for this mission shows), and the growth indicated for this portion reflects the additional resources required to staff the MSTMC.

In addition to managing mission-related contracts, the Laboratory maintains coordination with other technology management centers that administer fission programs, such as the centers associated with the Nuclear Standards and Consolidated Fuel Reprocessing programs at ORNL, the Reactor Fuels and Materials Program at HEDL, and the Fast Reactor Safety and Components programs at ANL. We also effect technology transfer through consolidated periodic technical summary (highlights) reports, management cost and milestone reports, and technical quarterly or semiannual progress reports; these documents are sent to DOE, ORO, all MSTMC participants, and related technology management centers. All participants and the U.S. industrial community are further informed through independently generated topical reports that the MSTMC consistently distributes in collaboration with the DOE Technical Information Center.

For the LMFBR program, there are 28 tasks nationwide: seven at ORNL; six at W-ARD; five at HEDL; three at ANL; two each at GE and INEL; and one each at RI, NRL, and Agbabian Associates.

Summary of resources – Materials and Structures Technology Management Center[a]

	'79	'80	'81	'82	'83	'84	'85
Operating costs							
National program	11.2	11.5	12.8	13.0	13.0	13.0	13.0
ORNL	4.1	4.4	5.3	5.3	5.3	5.3	5.3
MSTMC	0	0.5	0.6	0.6	0.6	0.6	0.6
Capital equipment	1.1	1.2	1.3	1.3	1.3	1.3	1.3
Subcontracting and procurement	1.0	1.1	1.3	1.3	1.3	1.3	1.3
Direct FTE[b]	46	51	51	51	51	51	51

[a]Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. Personnel numbers are in full-time equivalent (FTE) person-years.

[b]These figures represent Laboratory personnel.

Low-Level Waste Management Program (associate lead mission). This program seeks to develop environmentally sound techniques for the safe, efficient disposal of all types of low-level radioactive waste generated by such activities as energy production, manufacturing, and the use of radioisotopes in medicine and other fields. One program activity focuses on the development and improvement of waste treatment and packaging technologies. Others emphasize shallow land burial. Their objectives are to define problems in current shallow land burial

practices and subsequently to develop and demonstrate remedial measures for stabilizing and improving the performance of existing burial grounds. Furthermore, we are attempting to develop and demonstrate improved techniques for future shallow land burial operations, including site selection, waste emplacement, site stabilization, and final decommissioning. Yet another facet of this program is the development, evaluation, and demonstration of alternative methods of low-level waste storage and disposal.

A major milestone in the associate lead role is the completion of a detailed overall program plan. A draft was prepared in FY 1979, and the first complete version will be prepared in early FY 1980. This plan in turn will define milestones for the development and demonstration of low-level waste management technologies. We expect additional milestones related to the assessment of current practices for management of site wastes.

The Laboratory is responsible for supporting ORO—the associate lead field office for the national low-level waste management program—in the management of selected parts of the national effort. In this capacity, it interfaces with INEL/EG&G, which is the lead support contractor for the program's lead field office, Idaho Operations. Although ORNL will generally assist INEL/EG&G in the total program, we will emphasize the development of a base technology and concepts for alternative systems of processing and disposal as well as other assigned supporting functions. ORNL also provides technical staff input to the program and full services support in all business management areas.

ORO is responsible for providing ORNL with implementation-level policy, strategy, and programmatic direction in accordance with approved plans, schedules, and costs. It also supports the program by (1) assisting in the development of the low-level waste strategy document and the low-level waste program plan; (2) providing program guidance to other participating field units; (3) directing ORNL's performance in executing technical and financial aspects of the program; and (4) making recommendations to INEL on corrective changes in management, program scope, and funding.

In the associate lead role for the INEL/EG&G program, the Laboratory will direct technical activities in low-level waste management at other DOE multiprogram laboratories, including Los Alamos Scientific Laboratory (LASL), Mound Laboratories, Battelle Pacific Northwest Laboratories (PNL), Rockwell-Hanford, HEDL, and SRL. We also anticipate contracts with universities, commercial firms, and consultants. To fulfill a primary goal of the program, the Laboratory will make the low-level waste management technology derived from these R&D activities available to industry and to federal, state, and local governments.

Of the related DOE programs, several are in nuclear waste management under the Assistant Secretary for Energy Technology, including those concerned with airborne transuranium high-level wastes, transportation of wastes, decontamination and decommissioning, and waste isolation. Several others are in coal technology under the Director of Energy Research; these emphasize fly ash and coal conversion residues and ash disposal. Moreover, a number of programs under the Assistant Secretary for the Environment are pertinent to this program—for example, those focusing on environmental control R&D, environmental monitoring, and environmental data bases.

The R&D activities carried out at ORNL facilities for the national low-level waste management program are covered by the following Work Element Plans: OR 3.1.1, OR 3.2.5, OR 3.5.1.1, OR 3.5.3.1, OR 3.5.3.2, OR 3.5.4, OR 3.5.5, OR 3.10.1.1, OR 3.10.1.2, and OR 3.10.2. In addition, the Laboratory is responsible for overall management of technical activities for the low-level waste program; many of these activities are executed by other DOE facilities and contracted organizations under numerous Work Element Plans. The funding support for the overall national technical activities managed by ORNL is about $6.5 million and is expected to grow.

Summary of resources – Low-Level Waste Management Program[a]

	'79	'80	'81	'82	'83	'84	'85
Operating cost	2.5	3.3	3.5	4.5	4.8	4.6	3.9
Capital equipment	0.1	0.2	0.3	0.5	0.5	0.4	0.3
Subcontracting and procurement	0.2	0.9	0.8	0.9	0.8	0.5	0.3
Direct FTE[b]	31	32	33	43	48	50	44

[a]Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. Personnel numbers are in full-time equivalent (FTE) person-years.

[b]These figures represent the staff required to accomplish ORNL's part of this associate lead mission.

ELMO Bumpy Torus Research and Development (proposed role). The ELMO Bumpy Torus (EBT) is the leading alternative to tokamaks and mirrors—the two magnetic fusion concepts that are being studied extensively and show promise of being able to produce reactor-level parameters. Developed at ORNL, the EBT concept is the most promising in terms of demonstrated performance and reactor potential. Consequently, it has been selected by DOE for advancement to the proof-of-principle stage. The program's major milestone will be operation of the EBT-P facility in late FY 1983.

Our role is that of managing the research necessary to advance this concept to a level at which its potential could be evaluated and compared with that of tokamaks and mirrors. This involves experiment, theory, reactor studies, and coordination with other construction projects that might become involved. Central to this effort is the participation of industry to provide a base for EBT development.

ORO will provide ORNL with implementation-level policy, strategy, and programmatic direction in accordance with approved plans, schedules, and costs. Its other responsibilities will include (1) assisting in the development of the national management plan and the national program plan; (2) providing program guidance to other participating field units; (3) directing ORNL's performance in executing technical and financial aspects of the program; (4) making recommendations to DOE Headquarters on corrective changes in management, program scope, and funding; and (5) providing technical staff input to the program and full services support in all business management areas. The responsibilities of ORNL, DOE/ORO, and DOE/ETM are further delineated in a memorandum of March 1979.[6]

The design and construction of EBT-P will be supported through a major subcontract with an industrial participant. Subcontracts have already been established with two California firms—Varian Associates in Palo Alto and Hughes Aircraft in Compton—for the high-power tube development, which is being conducted by the Office of Fusion Energy (OFE), Division of Development and Technology (D&T), and is being managed by ORNL. In addition, several subcontracts will be used to support the EBT theory program and to develop ion cyclotron resonance heating, advanced pumping systems, and divertors on EBTs.

This program is covered by the following Work Package Proposal and Assignment System (WPAS) numbers: D&T—Superconducting Magnet Development, EBT II Coils, No. 00131; D&T—Elmo Bumpy Torus II, No. 00009; Elmo Bumpy Torus—Proof of Principle, No. 00127; and Elmo Bumpy Torus Theory Addition, No. 00115.

Summary of resources – ELMO Bumpy Torus Research and Development[a]

	'79	'80	'81	'82	'83	'84	'85
Operating cost	4.9	12.1	25.6	26.6	19.6	18.0	18.0
Capital equipment	0.3	13.0	3.2	1.4	0.7	0.7	0.7
Subcontracting and procurement[b]	2.1	9.8	20.5	20.0	16.0	15.0	15.0
Direct FTE	20	23	23	23	23	23	23

[a]Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. Personnel numbers are in full-time equivalent (FTE) person-years.

[b]These subcontracts and procurements are associated with EBT-P.

Laboratory Engineering Test Facility—Planning and Preconceptual Design (proposed role). The Engineering Test Facility (ETF) represents the phase of the fusion program following the phases of the Toroidal Fusion Test Reactor and the Mirror Fusion Test Facility; its purpose is to provide a test bed for fusion components, materials, and operation. Over the past few years, several laboratories have conducted advanced design studies of the ETF. The selection of ORNL as the lead laboratory for this mission will consolidate these efforts and establish a central design site for a preconceptual design effort, which will eventually lead to a request for commitment to the ETF. The programmatic milestone, for the end of FY 1981, will be completion of a set of documents including the preconceptual design, schedule, and cost and of an R&D document establishing interfaces between the development technology and the plasma physics program in the context of implementing the ETF.

To fulfill its role in this project, the Laboratory will provide a project manager, one of three associate managers, and about one-third of the supporting staff. It will also ensure coordination with institutions

[6]Energy Technology—Magnetic Fusion (ETM), ORO, and ORNL, "ETM/ORO/ORNL Memorandum of Agreement—EBT Proof-of-Principle Project," signed by Edwin Kintner, Joseph Lenhard, and Herman Postma, Mar. 27, 1979.

doing supporting R&D and with other laboratories having ETF interests and will have overall responsibility for the preconceptual design effort.

ORO will be responsible for providing ORNL with implementation-level policy, strategy, and programmatic direction in accordance with approved plans, schedules, and costs. It will lend additional support to the project by providing (1) assistance in the development of the national management plan and the national program plan, (2) program guidance to other participating field units, (3) technical staff input to the program, and (4) full services support in all business management areas. ORO will also direct ORNL's performance in executing technical and financial aspects of the program and make recommendations to DOE Headquarters on corrective changes in management, program scope, and funding.

We expect three major subcontracts with industry to be bid for work involving engineering; most of this work will be carried out at the lead laboratory site. Between one-half and two-thirds of the work should be subcontracted to industry. This program will be covered by WPAS No. 00035, Engineering Test Facility Design Center.

Summary of resources – Laboratory Engineering Test Facility[a]

	'79	'80	'81	'82	'83	'84	'85
Operating cost	0.6	3.0	4.0	10.0	10.0	10.0	10.0
Capital equipment	0	0	0	0	0	0	0
Subcontracting and procurement	0.2	1.7	2.4	5.1	5.0	5.0	5.0
Direct FTE	3	3	4	6	6	6	6

[a]Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. Personnel numbers are in full-time equivalent (FTE) person-years.

Superconducting Coils for Toroidal Confinement Systems (proposed role). The objectives of this mission are the design, fabrication, testing, and evaluation of large-bore, high-field superconducting magnets for toroidal fusion machines. Initial tests associated with this mission will be conducted at the Large Coil Test Facility (LCTF) using six D-shaped coils having magnetic fields of 8 T (measured at the conductor) and bores of 2.5- by 3.5-m; the test facility can accommodate one 5- by 7-m coil. Development programs designed to produce conductors suitable for fields of up to 12 T are already under way, and the magnets developed through these efforts will be directly applicable to toroidal machines in the near future and can be extrapolated to reactors.

Research and development activities will be carried out at ORNL as well as at other laboratories in direct support of the Large Coil Program (LCP), which provides an industrial magnet technology base to support magnetic confinement fusion. The LCP also involves international cooperation through the International Energy Agency, and we expect to test and compare the performance of three U.S. products and three foreign products—one each from Germany, Switzerland, and Japan.

Milestones for the program include completion of Phase II design activities by all LCP subcontractors in 1979 and delivery of coils by General Dynamics and GE in 1980. During 1981, two 12-T coils will be tested in the High-Flux Test Facility at Lawrence Livermore Laboratory (LLL), and Westinghouse will deliver its coil. The following year will produce three significant events: completion of the three domestic coil tests, delivery of the three foreign coils, and performance of the complete compact torus test.

In the performance of its lead laboratory role, ORNL will manage the LCTF, the procurement of LCP coils (eventually 12-T ones) from industry, the supporting R&D activities, and the development of conductors in industry. It will also provide guidance to the foreign participants and will coordinate the interface tasks involved in testing the foreign coils in the LCTF.

ORO will provide ORNL with implementation-level policy, strategy, and programmatic direction in accordance with approved plans, schedules, and costs. Other forms of support provided by ORO will include assistance in the development of the national management plan and the national program plan, program guidance to other participating field units, technical staff input to the program, and full services support in all business management areas. ORO will also direct ORNL's performance in executing technical and financial aspects of the program and make recommendations to DOE Headquarters on corrective changes in management, program scope, and funding.

Subcontracting for this work will continue to be extensive. Currently, General Dynamics (California), GE (New York), and Westinghouse (Pennsylvania) hold contracts to design and fabricate LCP coils. In addition, the Francis Bitter National Magnet Laboratory, Massachusetts Institute of Technology

(FBNML/MIT), and the National Bureau of Standards, Boulder, Colorado, are performing some R&D. Only about 8% of the R&D is done at ORNL: about 92% is subcontracted.

Work on the LCTF is being done by Pittsburgh-Des Moines Steel (Pennsylvania), which is responsible for the design and site fabrication of the vacuum chamber. TRW (Tennessee) is the subcontractor responsible for performing cryogenic analysis. About 93% of the funding for LCTF work is appropriated for in-house use (this figure includes procurement), and about 7% is appropriated for these two contracts.

Development and manufacture of the advanced conductor in order to meet specifications will be the responsibility of Airco (New Jersey), IGC (New York), and Supercon (Massachusetts); they will perform this task on a best-efforts basis. ORNL work on the conductor will total about 33%, while subcontracting to industry will account for about 67%.

General Dynamics (California) and GE (New York) will each design and fabricate a 12-T coil to fit in LLL's High-Flux Test Facility. The Laboratory will provide about 10% of this effort; about 90% will be subcontracted to industry.

The complexity and nature of this mission will necessitate the coordination of its efforts with those of related programs and industry. DOE programs requiring technical coordination with this one are the advanced systems studies, the long pulse experiments, the poloidal coil development, and the 12-T programs being managed at FBNML/MIT and at General Atomic. Furthermore, the program is designed to provide a technology base in industry, and all information gained from R&D is to be transferred directly to the companies responsible for building the coils being tested.

Summary of resources – Superconducting Coils for Toroidal Confinement Systems[a]

	'79	'80	'81	'82	'83	'84	'85
Operating cost	10.9[b]	11.5[b]	13.5[b]	5.4	3.0	3.6	3.6
Capital equipment	1.8	4.5	1.2	0.8	0.2	0.3	0.4
Subcontracting and procurement	8.9	8.2	6.0	0.6	0.6	0.5	0.5
Direct FTE	22	28	37	36	16	16	16

[a]Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. Personnel numbers are in full-time equivalent (FTE) person-years.

[b]This figure reflects the use of operating funds to build coils.

This program is covered by the following WPASs for FY 1979: D&T Magnet Systems Superconducting Magnet Development—LCP, No. 00011; D&T Magnet Systems Superconducting Magnet Development—LCTF (MDF), No. 00012; Large Coil Program R&D Activities, No. 00122.

Fossil Energy Materials Program (current role). The Fossil Energy Materials Program manages the national program of advanced R&D of construction materials for various fossil energy applications. Examples of these applications are mining and extraction technology; fossil fuel processing (gasification, liquefaction, and refining); fossil fuel utilization (heat engines and recovery, combustion, fuel cells, turbines, coal cleaning and preparation, and environmental control); magnetohydrodynamics; and supportive systems engineering.

The Laboratory is responsible for assessing the materials needs of fossil energy programs, developing plans in support of the program to meet those needs, and coordinating plans with supporting organizations. It develops program plans to meet DOE program objectives and identifies the facilities, program milestones, decision points, and cost schedules required to meet programmatic needs. Among its other responsibilities are (1) review of prospective program participants and their proposals, including detailed milestones; (2) participation in contract awards; (3) review of program progress and costs; (4) control of remedial measures for nonperformance; (5) maintenance of program records; and (6) dissemination of information to appropriate parties. Additional details of this assignment, which was proposed by ET and the Director of Fossil Energy Programs, are being negotiated with DOE Headquarters. All activities are performed with the approval of the responsible DOE offices. DOE not only provides the policy and guidance for program planning and the required resources, but it also retains overall accountability for the program.

ORO provides ORNL with implementation-level policy, strategy, and programmatic direction in accordance with approved plans, schedules, and costs. Its other responsibilities include (1) assisting in the development of the national management plan and the national program plan; (2) providing program guidance to other participating field units; (3) directing ORNL's performance in executing technical and financial aspects of the program; (4) making recommendations to DOE Headquarters on corrective changes in management, program

scope, and funding; and (5) providing technical staff input to the program and full services support in all business management areas.

To achieve this program's objectives, we will subcontract much of the work and will interact with related programs as appropriate. About 20% of the proposed work will be done at ORNL; the remainder will be subcontracted to other organizations, including other national facilities, industrial laboratories, and universities. In addition, we are responsible for overseeing publications, workshops, technical meetings, and interaction with professional societies and codes and standards organizations. These activities ensure full use of the data generated.

This program is covered by WPAS No. NEW 0028. Other information about the program is contained in the correspondence of J. A. Lenhard and J. T. Bartis.[7,8]

Summary of resources – Fossil Energy Materials Program[a]

	'79	'80	'81	'82	'83	'84	'85
Operating cost[b]	0.5	7.0	8.0	10.0	12.0	12.0	12.0
Capital equipment	0	0.5	0.6	1.0	1.0	1.0	1.0
Subcontracting and procurement	0	6.0	6.8	8.0	9.6	9.6	9.6
Direct FTE	6	12	15	20	24	24	24

[a]Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. Personnel numbers are in full-time equivalent (FTE) person-years.

[b]Cost estimates will be revised following further discussions with DOE Headquarters.

Supercharged Fluidized-Bed Combustor Program (proposed role). The objective of the Supercharged Fluidized-Bed Combustor (SCFBC) Program is to manage the research, development, and demonstration leading to the successful commercialization of the SCFBC. This assignment was discussed as a new initiative with ET staff members during the onsite review of ORNL on April 26, 1979, and in follow-up correspondence. Following completion of a program plan and discussions with DOE Headquarters, the milestones for the program will be defined. More information about the program is given in the chapter entitled "New Initiatives."

To fulfill its responsibility as lead laboratory, ORNL will assess the programmatic needs of the SCFBC Program, develop plans in support of the program to meet those needs, and coordinate plans with supporting organizations. Its program plans will meet DOE objectives and will identify the facilities needed, program milestones, decision points, and cost schedules. Prospective participants and their work plans, program progress, and program costs will receive ORNL review. The Laboratory's remaining responsibilities will include participation in contract awards, control of remedial measures for nonperformance, maintenance of program records, and dissemination of relevant information to appropriate parties. All activities will be performed with the approval of the responsible DOE offices. DOE will provide policy and guidance for program planning as well as required resources and will retain overall program accountability.

ORO will be responsible for providing ORNL with implementation-level policy, strategy, and programmatic direction in accordance with approved plans, schedules, and costs. It will lend additional support to the program by providing (1) assistance in the development of the national management plan and the national program plan, (2) program guidance to other participating field units, (3) technical staff input to the program, and (4) full services support in all business management areas. ORO will also direct ORNL's performance in executing technical and financial aspects of the program and make recommendations to DOE Headquarters on corrective changes in management, program scope, and funding.

The performance of the lead laboratory role will involve interaction with facilities and programs outside the Laboratory. A substantial fraction of the supporting R&D work will be performed at ORNL, with much of the remainder subcontracted to other organizations, including other national facilities and industry. In addition, technical coordination of the proposed work with that of two related DOE programs—the Atmospheric Fluidized-Bed Combustor (AFBC) and the Pressurized Fluidized-Bed Combustor (PFBC) development programs—may be necessary. Finally, we will ensure full use of the data generated through this program by overseeing publications, workshops, technical meetings, and interaction with industrial organizations.

[7]Letter from J. T. Bartis, Division of Planning, Coal Systems Engineering, to J. A. Lenhard, DOE—ORO, Subject: Fossil Materials Management Assignment, May 9, 1979.

[8]Letter from J. A. Lenhard, DOE—ORO, to J. T. Bartis, Division of Planning, Coal Systems Engineering, Subject: Fossil Materials Management Assignment, May 18, 1979.

Power Systems Technology (current role). This program seeks to establish the feasibility of load management as an energy conservation measure and to determine its costs and benefits to utilities and their customers. Load management, especially that in which the loads are utility controlled and energy storage is available at the points of use, is already considered beneficial in the conservation of oil and natural gas, an important national concern. By shifting the demand for power from peak to off-peak periods, load management in this application limits the use of inefficient oil and gas turbines for peak generation of electric power and reduces the need for additional generating capacity. Conservation can also be realized using utility-controlled loads without energy storage; this method results in reduction of peaks but only marginal shifting of loads.

The possibility of using load control for emergency shedding of selective blocks of load to avoid system breakup is the subject of additional research in load management. Other current work involves development of the methodology needed to assess the impacts, costs, and benefits of peak shifting, peak shaving, and emergency control and the impacts of locally dispersed generation and energy storage. The program is also concerned with the development and assessment of distribution automation and load control, including control of dispersed generation and storage. The integration of these new technologies into the utility system and the assessment of their energy conservation, economic, and operating impact are principal concerns of the program.

Important milestones include (1) establishment of the feasibility of utility control of industrial loads, FY 1980; (2) completion of field tests of communication systems, FY 1980; (3) assessment of the impact of dispersed generation on an isolated utility, FY 1981; (4) completion of demonstrations of utility-controlled heat-and-cool storage for load management, FY 1982; and (5) establishment of a large-scale demonstration test bed for distribution automation, load management, and integration of new dispersed technologies in a Tennessee Valley Authority (TVA) distributor's system, FY 1984.

The Laboratory performs in-house R&D, conducts program planning, selects subcontractors, and supervises subcontractors and demonstrations. ORO provides ORNL with implementation-level policy, strategy, and programmatic direction in accordance with approved plans, schedules, and costs. Additional program support from ORO includes (1) assistance in the development of the national management plan and the national program plan, (2) program guidance to other participating field units, (3) technical staff input to the program, and (4) full services support in all business management areas. ORO also directs ORNL's performance in executing technical and financial aspects of the program and makes recommendations to DOE Headquarters on corrective changes in management, program scope, and funding.

Currently, we have released or plan to release 14 subcontracts, most with U.S. utility companies, for demonstrations to develop data for assessing the impact of load management on utility systems and to establish cost benefits for utilities and their customers. Other contracts are related to the survey and assessment of load management activities and to new technology integration. Ten of these contracts are for demonstration of heat-and-cool storage devices in residences, and one is for evaluation of utility-controlled load management of industrial customers. The utilities involved range from Pacific Gas and Electric, a large investor-owned firm, to the municipally owned system of the city of Burbank, California.

This work interfaces with the residential and commercial conservation efforts, the solar activities, and the Low-Temperature Thermal Energy Storage Program. In addition, the use of utility companies, consulting firms, and manufacturers as subcontractors for this program facilitates the transfer of new technology about load management and may result in successful large-scale demonstrations of this conservation method in the near term.

Summary of resources – Power Systems Technology[a]

	'79	'80	'81	'82	'83	'84	'85
Operating cost	4.1	6.9	8.9	8.9	8.9	8.9	8.9
Capital equipment	0.1	0.1	0.1	0.1	0.1	0.1	0
Subcontracting and procurement	3.7	6.2	8.3	8.3	8.3	8.3	8.3
Direct FTE	7	8	8	8	8	8	8

[a]Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. Personnel numbers are in full-time equivalent (FTE) person-years.

This program is covered by the following WPASs: Technical Monitoring of Load Management Projects, C1 07 01 02 0; DOE Technical Analysis and

Monitoring for Field Tests of Communication Systems for Distribution Automation, C1 07 01 03 0; and Participation in US/USSR Superconducting Power Transmission Cooperation, C1 07 02 01.

Environmental Impact Assessment for Fossil and Geothermal Energy (current role). As the lead laboratory for this mission, ORNL is to ensure that DOE's environmental obligations under the National Environmental Policy Act are met and that environmental considerations are an integral part of fossil, geothermal, and also solar technology research, development, and demonstration. To this end, we will continue to develop and maintain centers of expertise in the environmental aspects of these technologies through preparation of site and program environmental impact statements. In addition, we will manage environmental impact assessment tasks and provide technical review and quality control of the work of other laboratories, universities, and subcontractors.

Milestones in the environmental analysis activities are keyed to programmatic decision points. We have, however, identified several specific reports that can be used to mark the program's progress. These include six project-specific draft environmental impact statements in fossil energy that are to be completed during mid-to-late 1979 and two project-specific environmental statements and eight project-specific environmental assessments in geothermal energy that are to be prepared each year. In addition, four programmatic environmental assessments in solar energy are due by the end of 1979.

The Laboratory is responsible for the technical direction of the program, including definition of program requirements and coordination of activities of other contractors. ORO has the responsibility of program surveillance for the Assistant Secretaries of Energy Technology and Resource Applications. In this capacity, it provides the Laboratory with implementation-level policy, strategy, and programmatic direction in accordance with approved plans, schedules, and costs; directs ORNL's performance in executing technical and financial aspects of the program; and makes recommendations to DOE Headquarters on corrective changes in management, program scope, and funding. In addition, it furnishes assistance in the development of the national management plan and the national program plan, program guidance to other participating field units, technical staff input to the program, and full services support in all business management areas.

ORNL currently has subcontracts with five firms to provide technical assistance in the preparation of environmental assessments and statements: (1) Science Applications, Inc., Oak Ridge, Tennessee; (2) Lockheed, Huntsville, Alabama; (3) NUS, Inc., Rockville, Maryland; (4) Coastal Environments, Inc., Baton Rouge, Louisiana; and (5) Roy F. Weston, Inc., West Chester, Pennsylvania. Participation ranges from performance of a small percentage of the total analysis for a project to preparation of a complete document in the subcontractor's shop. In addition to these five subcontractors, others throughout the United States are available on short notice to provide assistance or finished products.

This program is covered by the following reference documents: Geothermal Loan Guaranty Environmental Analysis; Environmental Analysis of Geothermal Energy, No. 00004; Fossil Energy Environmental Project, No. 00076; Program Plan for the Fossil Energy Environmental Project, FY 1978, October 1977.

Summary of resources – Environmental Impact Assessment for Fossil and Geothermal Energy[a]

	'79	'80	'81	'82	'83	'84	'85
Operating cost	3.6	4.1	4.9	5.9	4.1	3.5	3.5
Capital equipment	0	0	0	0	0	0	0
Subcontracting and procurement	1.5	2.0	2.7	3.7	2.1	1.5	1.5
Direct FTE	19	19	19	19	19	19	19

[a]Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. Personnel numbers are in full-time equivalent (FTE) person-years.

Director of Energy Research

The basic physical sciences programs at ORNL are conducted on behalf of the Director of Energy Research and have operated at a fairly constant level during the past five years. The staff level associated with these programs is expected to increase about 1% per year during this planning period. Growth is expected in materials sciences research related to the High Temperature Materials Laboratory (HTML), in chemical sciences research in coal chemistry and waste disposal, and in nuclear physics research at the Holifield Heavy Ion Research Facility (HHIRF). Radiation damage research and superconductivity research in the Metals and Ceramics Division, however, will be phased out. The emphasis in basic

physical sciences programs has shifted from fission-related work to nonnuclear- and fusion-related work—a trend that should continue but should do so more slowly. In addition, growth of the Laboratory's basic physical sciences research may be affected by continuing problems related to the support of large basic-research facilities, including the High Flux Isotope Reactor (HFIR) and the existing EN Tandem Van de Graaff Accelerator.

Basic Energy Sciences (AK 01)

Technical Thrust

The basic energy sciences program at ORNL includes research in nuclear, materials, chemical, and engineering sciences; in mathematics and statistics; and in atomic physics. These efforts comprise both experimental and theoretical work and involve substantial interaction with outside users of ORNL's basic energy science facilities.

Nuclear Sciences (AK 01 01). The experimental nuclear sciences program includes measurements of neutron cross sections that enhance basic understanding of the theory of nuclear interactions as well as measurements that are necessary for the economic exploitation of fusion and fission energy. We have a continuing need for these types of data. For example, studies of alternative (nonproliferating) fuel cycles and of improved fuel utilization for existing light-water reactors have identified important new nuclear data requirements. The Oak Ridge Electron Linear Accelerator (ORELA) is the best facility in the world for supplying such data, and we are working to improve further its machine characteristics. An accelerator improvement project is under way that will increase the neutron source strength for all measurements using pulses of about 5 nsec; this improvement will increase the variety of experiments that can be run simultaneously.

Other program activities include light-ion nuclear physics research, transuranium element production, stable isotopes separation, study of the chemistry of transuranium elements and compounds, and the systematic collection and critical evaluation of nuclear data. In addition, we propose further development of ORNL's recently demonstrated and very exciting technique of one-atom detection. A new goal of this development is to be able to detect single ^{7}Li and ^{71}Ge atoms; both atoms are important in the measurement of the solar neutrino flux, which in turn may remove the current dilemma over the origin of solar energy.

In light-ion nuclear physics, research has led to the discovery and understanding of new nuclear resonances, and the systematics of the monopole resonance as a function of nuclear mass has been studied. We are also conducting light-ion nuclear physics research at the Indiana University cyclotron.

With respect to stable isotope separation, we are continuing to provide most of the highly enriched, separated, stable isotopes and selected radioisotopes, including actinides, to the research and commercial communities. Research and development (R&D) is directed toward improving physical and chemical processing of separated isotopes in order to improve their isotopic and chemical purity.

Research in the chemistry of transuranium elements and compounds seeks to solve problems relating to the behavior of actinides in the environment and in nuclear waste repositories as well as to gain an overall understanding of their chemical properties. Not only are many experimental techniques, including microcalorimetry and electrochemistry, being used, but capabilities in laser Raman spectrometry and magnetic susceptometry are also being developed. Research is focusing on the preparation of actinide metals and the determination of their properties; the investigation of unusual oxidation states of actinide compounds; the adsorption of uranium, neptunium, and plutonium on selected minerals; and the speciation of actinides in solutions of environmental interest.

Through the Nuclear Data Project, the Laboratory continues to provide technical support and leadership for programs concerned with the collection, critical evaluation, and use of nuclear spectroscopic data. The project's files of indexed references and spectroscopic data, together with the regularly published *Nuclear Data Sheets,* are key resources for the nuclear science community. In addition, the project provides a strong link between the basic science measurements and the users of those measurements in areas of applied technology, such as fusion reactor design, nuclear waste isolation, and standards for medical applications.

Materials Sciences (AK 01 02). The materials sciences research program deals with fundamental studies of mechanical, physical, chemical, optical, electrical, and magnetic properties of materials. The work is guided by the needs of the DOE missions.

Among the experimental programs are investigations of crystal structures, phase transitions, superconductivity, physical and transport properties, radiation effects, magnetic phenomena, surface properties, lattice dynamics, deformation and

mechanical properties, welding and joining, corrosion, and fracture.

In one experimental program, techniques used to study the microstructure of metals are being adapted to characterize the microstructure of various coals. In another, studies of tritium chemical equilibria and permeation are being performed in support of the fusion energy program. Vital basic research is also being performed on diverse energy-related materials problems, such as photovoltaic conversion in solar cells, stress-corrosion cracking in reactor containment vessels, storage of nuclear wastes in minerals, and ionic conductivity in solid electrolytes for batteries and fuel cells.

Further experimental work involves investigations using ion implantation and laser annealing. These techniques have produced photovoltaic cells with excellent efficiencies that compare well with the best cells made by standard procedures. They can also be used to produce new metastable alloys and have led to an improved understanding of crystal growth processes.

The radiation effects program supports the breeder reactor and magnetic fusion programs by providing an understanding of the effect of alloying elements on dimensional stability and on the phenomenon of radiation-induced creep. We are studying defects produced by energetic neutrons or ions in order to improve our comprehension of displacement cascades and the clustering of point defects.

Recently developed programs in engineering materials sciences are aimed at providing a scientific basis for nondestructive evaluation techniques. Specifically, they investigate the erosion of ceramics—especially subsurface-region deformation—on a microscale; the principles governing the microstructure and properties of metal formed under conditions typical of welding; and the interaction of acoustic waves with the materials parameters.

The deformation and mechanical properties program has recently been redirected to address the effect of impurities and interfaces on deformation and fracture of metals likely to be used extensively in the construction of energy systems in the near future. Its studies examine thermal properties of metals and nonmetals, oxidation and sulfidation of iron-based alloys, and migration of interstitial elements (hydrogen and deuterium) through oxides. Important contributions have been made to understanding flux pinning and the effects of stress on superconducting properties.

Coupled closely to the experimental work in materials sciences are the theoretical investigations, which are concerned with electronic and magnetic properties, lattice dynamics, surface physics, particle-solid interaction, and laser annealing. Currently, our efforts on the theory of metals and alloys provide support for studies of systems in which phase stability is important.

Several large, unique facilities are available for research in the materials sciences. Included among them are (1) a variety of neutron-scattering facilities at the HFIR, which furnishes the most intense beams of thermal neutrons now available for research; (2) facilities at the Bulk Shielding Reactor (BSR) for closely controlled investigations of radiation effects at very low temperatures; (3) several accelerators for research in ion radiation damage, ion implantation, ion scattering, and ion channeling; (4) high-voltage and high-resolution electron microscopes; and (5) a 10-m small-angle x-ray-scattering camera. Users groups have been formed in association with the National Science Foundation (NSF) and Oak Ridge Associated Universities (ORAU) to share these unique facilities and to participate in the development of an instrumented beam line for the National Synchrotron Light Source (NSLS) now being constructed at Brookhaven National Laboratory (BNL).

Chemical Sciences (AK 01 03). The chemical sciences research program embraces the broad range of disciplines appropriate for developing the scientific base needed to support the several energy areas. The work focuses on synthetic and physical organic chemistry; thermodynamics, separations science, and aqueous chemistry; catalysis at surfaces and in molten salts; chemical physics and theoretical chemistry; photon and radiation chemistry; analytical chemistry; and the use of atomic and ionic beams.

Although these areas of research are part of different disciplines, they often interact to produce fresh insights into a given energy area. Efforts in organic chemistry, electron spin resonance, and nuclear magnetic resonance, for example, are now contributing significantly to new understandings of coal pyrolysis, liquefaction reactions, and molecular structure. Using molecular beams, we are investigating primary-level carbon-hydrogen reactions.

Separations science is returning as a key field because of its importance in nuclear waste isolation, materials resource recovery, and coal processing. Topics being pursued at the Laboratory include new

developments in hydrometallurgy, chromatography, and solvent extraction. Aqueous chemistry research is providing basic chemical and thermodynamic data on solutions encountered in such diverse areas as geothermal brines, nuclear waste isolation in salt deposits, and steam generator systems.

In the area of catalysis, new approaches that employ electron spin resonance and other means are overturning previous ideas of the molten-salt catalytic reactions of aromatic hydrocarbons modeling coal.

We are pursuing theoretical chemical sciences studies aimed at gaining a better understanding and expanded applications of the Schrödinger equation: these are needed to make comparisons with experiments involving new ways that photons can interact with molecules. Furthermore, research on the statistical mechanical theory of liquids is achieving breakthroughs leading to the ability to calculate hydrocarbon thermodynamic functions. It is hoped that in the next few years the methods under development will give a similar capability for aqueous and molten salt solutions.

Other research focuses on the thermochemical production of hydrogen and photochemical studies of importance in combustion. Analytical chemistry research techniques are being developed for identifying the components of a wide variety of materials, including potentially hazardous by-products of coal conversion processes.

Basic atomic data are essential to the understanding of plasma impurity effects in the fusion program. Multicharged ion beams from the EN Tandem Van de Graaff Accelerator will be merged with an electron beam to determine electron ionization and dielectronic recombination cross sections. We will continue to use crossed- and merged-beam techniques to measure atomic collision cross sections for electron excitation, electron ionization, and low-energy charge exchange—processes that are important in plasma energy loss and transport. New programs will be initiated in applications of energetic heavy-ion beams, individual excited-state selection cross sections or reaction rates for atoms and molecules, and nonequilibrium plasmas as related to energy research. These activities will be performed on both the EN Tandem Van de Graaff Accelerator and the HHIRF. Theoretical efforts related to the use of atomic and ionic beams are closely correlated with the experimental progress.

Engineering, Mathematical, and Geosciences (AK 01 04). Research in the engineering sciences emphasizes several new areas, including fluid dynamics, advanced techniques for industrial and electric power development, thermal processes, solid mechanics, process and system dynamics and control, reliability and risk analysis, and novel techniques for energy technologies. Mathematics research deals with moving-boundary problems, continuum mechanics, statistical methods, and numerical analysis. By FY 1985, our mathematics research effort should increase by about 40%; particular emphasis will be given to numerical linear algebra and moving-boundary problems. Programs in the geosciences, especially in geochemistry, emphasize chemical migration in the earth's crust and modeling of igneous rocks.

Advanced Energy Projects (AK 01 05). Research in this area is directed toward developing the technology base for a unique class of high-temperature ductile alloys that are needed for specific mission-oriented programs. In addition to this research and as part of a lead mission assignment, an in-depth study of the status of and need for basic scientific research supporting the U.S. effort to develop fossil energy is being carried out.

Biological Energy Conversion and Conservation (AK 01 06). ORNL research in this new subactivity, which is expected to begin on a small scale in FY 1980, should show moderate growth in FY 1981. We will emphasize fundamental studies of biological phenomena related to energy production and conservation. Of particular interest will be the study of microbiological systems that can be used for the production of fuels and useful chemicals.

Major Changes

These programs will shift from research primarily concerned with fission energy technologies to research applicable to the technologies of fusion, fossil, solar, and geothermal energy and of conservation. Our materials research will focus on the properties of materials at very high temperatures in hostile environments and the development of new types of materials through nonequilibrium processes, primarily through laser-surface interactions. In chemistry research, more emphasis will be given to coal chemistry—especially to the structure of coal, reactions of coal constituents, and high-temperature materials chemistry. Parts of the x-ray and surface research programs will shift from the use of conventional sources to the use of synchrotron sources, which are located primarily at BNL. We will initiate new work in engineering science, geochemistry, and resource recovery and will

maintain a diversified fundamental research program to support the research directed toward energy technology.

Major Issues

The basic energy sciences program supports two unique research facilities, the HFIR and the Transuranium Processing Plant (TRU). The HFIR is the highest flux reactor in the country, which makes it an ideal device for activation analysis and advanced analytical technique development; it supports an exceptional multifaceted research program. The neutrons in its flux trap are used for production of transplutonium elements, which constitute the only U.S. source of research quantities of the very heavy elements (e.g., einsteinium and fermium), and for the study of fusion-related radiation damage. Furthermore, neutron beams from the HFIR are used to study solids and liquids and continue to produce unique information about magnetic structures of solids, crystal structure, lattice dynamics, and correlation functions in organic liquids and molten salts. A small-angle neutron-scattering facility is currently under construction at the HFIR, and beginning early in 1980, it will be used to study biological materials, polymers, and dislocations in metals.

The TRU is a heavily shielded chemical separation facility used along with the HFIR to separate heavy elements. It is also the nation's only instrumented chain of hot cells in which experimental chemical separations can be conducted on highly irradiated spent fuel. As such, it is an unparalleled U.S. resource. We intend to keep both of these productive, unique facilities operating, in spite of funding difficulties. But because support for their operation comes from many parts of DOE and because the research they house cannot sustain fluctuations in funding, we have serious problems in maintaining the research programs and operation of these facilities at productive levels.

A second major issue in this program is the continuing support for the EN Tandem Van de Graaff Accelerator, which is instrumental in producing new and original research. Research on this machine now concentrates on atomic physics and materials science. Besides being used by ORNL scientists, the EN Tandem is a users facility that served 66 people from universities and other laboratories in the past year. Highly instrumented installations such as this accelerator are a national asset and should be maintained as long as their research is truly innovative. However, ensuring the accelerator's continued operation will require significant additional support from the chemical sciences program.

High-Energy Physics (HK 02)

Technical Thrust

As part of our effort in high-energy physics, experimental investigations of high-energy interactions of hadrons, baryons, and leptons are performed in bubble chambers to obtain information on the properties of elementary particles and their interaction characteristics. In addition, calculations pertaining to the design of accelerator shields and detection instruments are being used in the design of essentially all high- and medium-energy accelerators in the United States (e.g., ISABELLE at BNL). Related calculations are made for facilities to study radiation damage in fusion-energy devices [e.g., the Fusion Materials Irradiation Test (FMIT) at Hanford Engineering Development Laboratory (HEDL)]. Throughout this planning period, the high-energy physics programs should remain stable and should involve continued collaborations with the University of Tennessee (UT) faculty.

Nuclear Physics (HK 03)

Technical Thrust

ORNL's nuclear physics program is dominated by the topics related to heavy-ion physics. The development of Phase I of the HHIRF, for instance, constitutes a significant portion of the nuclear physics program. Installation of the new 25-MV tandem electrostatic accelerator is proceeding well; preliminary voltage tests, performed without acceleration tubes, attained 32 MV. Installation of the remaining accelerator components and beam transport systems should be completed in FY 1980, and testing and first experiments should follow later in the year. At that time, the nuclear physics program will emphasize experiments using projectiles having energies of up to 25 MeV/amu and will include plans to upgrade the facilities later in the decade—through Phase II of the HHIRF—to produce energies of up to 400 MeV/amu.

Currently, more than 300 scientists representing over 120 institutions are involved in planning for HHIRF operation through a formal users organization. A new facility, the Institute for Heavy Ion

Research, is being funded by DOE, Vanderbilt University, and UT and will be built to provide office, laboratory, and dormitory space for HHIRF users.

The theoretical nuclear physics program has developed to support the experimental physics research. For low-energy heavy-ion physics, the Time-Dependent Hartree-Fock mean-field approximation gives a good qualitative description of observed phenomena. A new program of study of the Coulomb-induced fission reaction has begun; the high-precision, high-intensity beams of Phase I will make it an outstanding facility for the study of this process. In addition, we are developing programs to perform hydrodynamic model calculations of heavy-ion collisions for comparison with experiments at higher energies, such as those proposed for Phase II. These calculations will be used to analyze high-energy data on nuclear compression as they become available.

Major Issues

The theoretical physics program requires excellent high-speed computing capabilities. New computers, which are being leased to ORNL, will have substantially larger user charges that will affect the theoretical physics program. A significant amount of additional support will be needed to allow performance of the calculations necessary for comparison with the anticipated large body of experimental data; such comparison will facilitate the planning of future experiments.

Lead Missions for the Director of Energy Research

Experimental Program Management for the Holifield Heavy Ion Accelerator (current role). The objective of this program is to provide a broad selection of accelerated heavy ions and the related experimental facilities required to support a national program in heavy-ion research. The program is charged with operating the 25-MV tandem electrostatic accelerator and with developing and fabricating state-of-the-art experimental devices required by experimenters using ion beams from these accelerators. Also included in the program is the performance of development studies leading to the addition of a more powerful booster accelerator to enhance further the capabilities of the HHIRF.

The program's major milestones for FY 1980 include demonstration of the performance of the 25-MV tandem electrostatic accelerator, operation of the cyclotron as a booster accelerator, and initiation of an experimental program with completed accelerators. In addition, we foresee completion of beam lines to all experimental stations in FY 1982 and preparation of a proposal for a new booster accelerator in FY 1984.

The Laboratory is responsible for the program's technical direction and management. The technical direction closely follows the recommendations of a Laboratory-appointed Program Advisory Committee and a representative of all facets of the users community. The management is monitored and evaluated by a Policy Review Committee composed of nationally recognized experts in this field and is coordinated with the Executive Committee of the Users Organization. Throughout the program, we will maintain a close liaison with DOE Headquarters staff. The Oak Ridge Operations Office (ORO) provides technical staff input to the program and full services support in all business management areas.

The accomplishment of this mission will involve the Laboratory in interaction with other institutions and programs and with industry. We have subcontracted Washington University, St. Louis, to provide design and fabrication of a specific experimental device (a spin spectrometer) and will probably establish other similar subcontracts. A related DOE program—Experimental Program Management for the Super-HILAC/BEVALEC—will afford another opportunity for interaction, as will the fulfillment of our technology transfer and commercialization responsibilities to manufacturers of both nuclear equipment and particle accelerators.

This program is covered by the following Work Package Proposal and Assignment System (WPAS) numbers: No. 00016, No. 00017, and No. 00018.

Summary of resources – Experimental Program Management for the Holifield Heavy Ion Accelerator[a]

	'79	'80	'81	'82	'83	'84	'85
Operating cost	2.5	3.1	3.8	4.0	4.2	4.3	4.3
Capital equipment	0.6	1.0	1.3	1.5	1.1	0.8	0.8
Subcontracting and procurement	0.2	0.2	0.2	0.2	0	0	0
Direct FTE	30	35	36	39	41	42	42

[a]Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. Personnel numbers are in full-time equivalent (FTE) person-years.

Experimental Program Management for the High Flux Isotope Reactor (current role). This mission seeks to provide neutron irradiations and neutron beams, largely for such DOE activities as the production of transplutonium isotopes and neutron-scattering studies but also for the scientific community and for commercial users, in cases approved by DOE. The Transplutonium Committee distributes the transplutonium isotopes produced, and irradiation and beam facilities are allocated by technical management.

The ^{252}Cf separated at the adjacent TRU facility, along with significant quantities of berkelium, einsteinium, and fermium, composes the main supply of these heavy elements for use in research and in various branches of science and industry. We are currently investigating the feasibility of providing about 40 μg of 276-day ^{254}Es (about ten times the current production) for use in the search for superheavy elements.

The HFIR provides the most intense thermal neutron flux and neutron beams currently available for research. It also produces a large portion of the national requirement of certain radioisotopes that commercial facilities cannot produce in the required amounts or types. Excellent facilities are available at the HFIR for various types of elastic and inelastic neutron-scattering experiments using either polarized or unpolarized neutrons. These facilities are used not only by ORNL staff members but also by many scientists from universities and other laboratories. Through an interagency agreement between DOE and NSF, a user-oriented National Center for small-angle neutron scattering has been established at ORNL, and we are now constructing a sophisticated small-angle neutron-scattering facility at the HFIR as part of this program.

The Laboratory is responsible for the technical direction of portions of this program and provides technical support to DOE Headquarters staff concerning coordination with other contractors or private users. In addition, we approve and schedule neutron-scattering experiments proposed by our scientists and those from other organizations. ORNL management of the national user-oriented small-angle neutron-scattering facility now being constructed will be consistent with ORNL, DOE, and NSF policies; experiments for this facility will be selected through a program committee's proposal review. ORO provides technical staff input to the program and full services support in all business management areas.

Subcontracting for this mission consists of the fuel manufacturing contract with Texas Instruments. Under a cost-plus-fixed-fee contract, the Texas firm has manufactured all HFIR fuel, except the first experimental elements, and will continue to perform this service. This subcontractor's work has now been expanded to include fuel for the Oak Ridge Research Reactor (ORR), the High Flux Beam Reactor at BNL, and the National Bureau of Standards Reactor.

We maintain coordination of the activities of this mission with those of the Office of Nuclear Material Production's californium utilization program, which is closely associated with the HFIR and the TRU. Other related programs are in basic chemistry and physics, the nuclear fuel cycle, and waste isolation. In addition, close coordination is maintained with neutron-scattering programs at BNL, Argonne National Laboratory (ANL), Los Alamos Scientific Laboratory (LASL), the National Bureau of Standards, the Massachusetts Institute of Technology, and the University of Missouri. Scientists from Ames Laboratory now reside at ORNL and use neutron-scattering equipment that was transferred from the Ames Laboratory Reactor to the ORR. Furthermore, many research laboratories throughout the United States conduct experiments with the transplutonium isotopes produced at the HFIR.

The californium technology gained through the performance of this mission is being applied in several areas, including neutron radiography, medicine, neutron activation, and oil-well logging. The subcontract for HFIR fuel manufacture has resulted in the transfer of the cermet fuel fabrication technology to private industry. Other technology transfer is being effected through program publications and cooperative irradiations and research conducted at the reactor. Scientific information obtained from neutron-scattering investigations is transferred through direct contacts with scientists from universities and other laboratories, papers at scientific meetings, open-literature publications, and division progress reports.

This program is covered by the following WPASs: No. 00012 and No. 00014.

Summary of resources – Experimental Program Management for the High Flux Isotope Reactor[a]

	'79	'80	'81	'82	'83	'84	'85
Operating cost	4.7	5.1	5.7	5.9	6.3	6.7	6.7
Capital equipment	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Subcontracting and procurement	1.0	1.1	1.1	1.2	1.3	1.4	1.4
Direct FTE	39	39	39	39	39	39	39

[a]Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. Personnel numbers are in full-time equivalent (FTE) person-years.

Assistant Secretary for the Environment

The Assistant Secretary for the Environment (ASEV) is responsible for life sciences and environmental programs in the GK and HK activities as well as for the decontamination and decommissioning of certain nuclear sites and facilities. The Laboratory's programs in these areas constitute 22% of its total R&D effort.

Environmental and Life Sciences Research

Technical Thrust

The biomedical and environmental sciences programs, which are funded primarily through the GK (Environmental Research and Development) and HK (Life Sciences Research and Biomedical Applications) resources, are concerned with identifying, understanding, and reducing the health and environmental impacts of energy production and use. Research activities include studies and assessments of the transport, fate, and effects of products and by-products of both nuclear and nonnuclear energy technologies from either a generic or basic science standpoint.

In its major programs, ORNL is conducting basic and applied research that will provide a better understanding of the health impacts and the environmental fate and effects of the effluents generated by coal utilization and conversion technologies. Research is being conducted in the Biology Division in areas related to carcinogenesis, mutagenesis, and toxicology; in the Environmental Sciences Division in ecosystem modeling and empirical measurements, environmental toxicology, and renewable resources; and in the Health and Safety Research Division in instrument development, assessment methodology development, epidemiology, and regional studies. The information thus gained is used to support holistic assessments of the impacts of technologies at the site-specific, regional, and global levels. Increased emphasis is being given to the tasks that are (1) developing an understanding of and the techniques necessary for safe nuclear and nonnuclear waste management; (2) investigating promising biotechnologies for waste treatment, resource recovery, and energy conservation; (3) developing ultra-low-level pollutant detection and measurement technologies; (4) developing disposal methods for hazardous wastes; (5) evaluating the biological effects of exposure to diesel fuel effluents; and (6) developing methods for determining health risks from exposure to nonnuclear pollutants.

Overview and Assessment (GK 01 01). The primary goal of this subactivity is to ensure that environmental, health, and safety impacts are considered in formulating and implementing energy technology decisions, plans, and programs. Toward this goal, ORNL has established the Office of Integrated Assessment and Policy Analysis to examine current and future policies related to the development and use of energy technologies and to provide DOE management with input enabling responsible decision making. The office performs critical analyses of criteria, land use requirements, and institutional arrangements established for the control of solid wastes from energy technologies. Particular emphasis has been placed on determining the effects of the Resource Conservation and Recovery Act (RCRA) and the Toxic Substances Control Act (TOSCA).

Policy-related research draws on the existing assessment capabilities developed to evaluate potential environmental, health, safety, and socioeconomic impacts at the site-specific, regional, and national levels. Increasing attention is being focused on site-specific and programmatic assessments of new energy technologies and related energy scenarios, and regional assessment methodologies are being refined and validated. To support these policy and assessment activities, we have established a broad base of information systems and data bases concerning environmental and safety as well as other aspects of various energy technologies.

Laboratory efforts in this subactivity also include environmental engineering for coal and nuclear technologies. The main objectives of these efforts are

(1) to determine the effectiveness and ensure the timely development of adequate environmental control capabilities for these technologies and (2) to evaluate the impacts of elevated CO_2 levels. In addition, efforts will be made to identify bioprocesses that can be used as control technologies for the various energy sources and for resource recovery.

From FY 1980 to FY 1985, we will continue our evaluation of RCRA and TOSCA and will examine other environmental legislation as it develops. We will also continue to assess the possible impacts of particular energy development scenarios. Furthermore, analysis and studies of timely policy issues will be conducted as requested by DOE. Future efforts in environmental engineering will focus on coal conversion processes, such as the H-Coal and the Solvent Refined Coal (SRC) processes.

As suggested by these long-range plans, our FY 1980 and FY 1981 activities will consist, for the most part, of continuations or accelerations of our current efforts. The Technology Overview and Assessment program, which is responsible for the preparation and revision of environmental development plans (EDPs), environmental readiness documents, and related assessments, will receive a funding increase to cover inflation only. In the Environmental Impacts and Information program, a small personnel reduction will occur in FY 1980 following completion of the National Energy Supply Strategy (NESS) impact assessment project in FY 1979. In other projects, the personnel levels will remain constant, while the dollar levels—especially in projects assisting the Environmental Impacts Division—will increase substantially in FY 1980. Funds requested for FY 1980 and FY 1981 for our Regional Assessment task, like those for the Technology Overview and Assessment program, include only an inflation escalation.

Short-term plans for our two Environmental Engineering programs differ. In FY 1980, the Environmental Engineering program for coal technologies should receive substantial funding increases for the following projects: Assessment of Environmental Control Technology (ECT) for Coal Conversion, HC and CO Effluent Control, Elevated CO_2 Effects on Terrestrial Ecosystems, and H-Coal Field Evaluation of ECT. A slight program decrease, however, is expected in FY 1981, as the Gasifiers in Industry—University of Minnesota–Duluth (UMD) task is reduced. In our Environmental Engineering program for nuclear technologies, we are requesting that the current level of effort be maintained through a cost-of-living funding increase. We are also proposing that funding be escalated for the Transportation Statistics Data Bank, because the expansion of the coverage of this data bank requires more computer and programmer time.

Current efforts in our Operational and Environmental Safety program, which focuses on Environmental Safety and Health (ES&H) Support and Assistance, will continue with no increase in funding in FY 1980 and only a cost-of-living increase in FY 1981.

Biomedical and Environmental Research (GK 01 02). The objective of this subactivity is to secure the information necessary for developing an understanding of the possible short- and long-term consequences of the processes involved in energy production and use. Because of DOE's increased interest in coal utilization, we expect some increase in this effort during this planning period. A primary goal is to evaluate the interaction of radiation and other energy-related pollutants with living organisms and ecosystems. This information is applied to ongoing DOE activities to ensure that they are conducted safely and effectively; that possible hazards are identified, evaluated, and anticipated; and that the overall environmental costs of the various energy options are accurately assessed.

In the major research programs, genetic and somatic testing systems are being developed to screen a variety of potentially hazardous substances in animal populations. In addition, many of the techniques developed during the past 30 years to study the human health risks resulting from radiation exposure are being applied to estimating the risks from exposure to energy-related chemicals. To support this research, new techniques are being developed for identifying the chemicals to which humans are exposed and determining the routes for exposure, the dose received, and the resultant health risks.

To provide a basis for determining the potential impact of the developing energy technologies, we are conducting programs to obtain information on the environmental transport, fate, and effects of energy-related pollutants. Major research efforts include the development of ecological test systems to support environmental hazard analysis. Our investigations of transport and transformation processes provide data on the fate of effluent components in the environment; such data are essential in determining critical pathways to man.

In another effort included in this activity, ORNL is performing site-specific health and environmental assessments of selected coal conversion facilities. The goal of the effort is to provide information enabling decision makers to ensure that processes for converting coal to synthetic fuels will not cause

unacceptable health and environmental risks when implemented on a commercial scale.

As indicated in the following long-range plans, additional study of the health and environmental aspects of coal utilization is needed. Determining the potential health effects of products and effluents from these coal technologies will require continuation of the long-term testing programs at the single-cell and whole-animal levels as well as the basic research required to elucidate the mechanisms of any resultant damage. The environmental research will focus primarily on determining the potential ecological impacts resulting from exposure to coal-technology products; in this, as well as in the health research, actual products and effluents from demonstration facilities will be used along with "model" compounds. Our environmental research will also investigate two phenomena that result from coal utilization: increased atmospheric CO_2 and acid precipitation.

Finally, the development of various monitoring devices (spill spotters, fugitive-emission analyzers, and skin-contamination detectors) will continue through field testing at demonstration plants. Additional efforts will focus on developing laser techniques for measuring very small quantities of energy-related materials.

In addition to these long-range plans, we have established several short-term, FY 1980 and FY 1981, programmatic directions. In the Human Health Effects from Energy Generation program, the ongoing tasks will continue at the same level of effort. However, a new task, Analytical and Health Effects of Gaseous and Particulate Effluents from Cooling Towers, is proposed for FY 1980.

We are requesting a significant funding increase for FY 1980 in our Carcinogenesis program for the following projects: Fission Neutrons and Gamma Rays, Dose Response Relation in Chemical Carcinogenesis, and Somatic Effects of Environmental Agents. In the Mutagenesis program, however, most of the tasks will continue at essentially the same level; changes include a slight increase in one task, Mammalian Genetics, and the transfer of another, Effects and Uses of Chromosome Aberrations, to Subactivity HK 01 01 in FY 1980. Several tasks in the Systems Damage program—Pollutants in Cardiovascular Disease, Chemical Toxicology, and Biotoxicity of Chemicals—will receive increased effort in FY 1980; the effort will then remain at a constant level for FY 1981.

Several changes will occur in the ORNL programs investigating the fate of energy-related pollutants in the environment. In FY 1980 in the Environmental and Energy-related Processes and Pollutants in the Environment program, minor personnel changes will occur. In-house effort will increase slightly and subcontract work substantially in the Environmental Transport and Effects of Coal Conversion Effluents task, and subcontracting for the Assessment of Gaseous Effluents from Coal Conversion will increase significantly. In FY 1981, 1 full-time equivalent (FTE) will be added to the Ecological Processes—Southeastern Reservoirs project. Although the estimated cost of the Identification, Transport, and Conversion of Energy-related Pollutants in the Environment program will increase significantly during this two-year period, personnel levels, as a result of additional subcontracting, will remain essentially the same. The decrease in the Physics and Chemistry of Pollutant Interactions in the Environment program reflects the FY 1980 transfer of the Physiochemical Properties of Chemical Pollutants, Biologically Active Molecules, and Related Structures task to Subactivity HK 01 01.

For the most part, other program efforts in the subactivity will increase in FY 1980 and FY 1981. A significant increase will occur in Energy-related Supporting Research as a result of a slight increase in the Biochemical Treatment of Waste Streams for Coal Conversion Processes task and the commencement of a new task, Utilization of Sulfur-cycling Microorganisms. Several minor changes in Environmental Operations and DOE Support Activities, the most significant of which will be an expansion of effort in the National Environmental Research Park Reference System project, will contribute to an increase in FY 1980 effort. After an increase in FY 1980, funding for Characterization Measurement and Monitoring will return to current levels in FY 1981; the projects that will receive additional funding in FY 1980 are Instrumentation Development for Monitoring Mutation Rates; Basic Measurement Science; Cell Cytometry, Personnel and Environmental Monitoring; Resonance Ionization Spectroscopy; and Gasifiers in Industry—UMD. Funding for the one task included in the Carbon Dioxide Effects Research and Assessment program, entitled Carbon Dioxide Research and Assessment, will increase in FY 1980 and FY 1981. Another program in which effort will decrease in FY 1980 is the Radiological and Chemical Physics program; the decrease will result from the transfer of the Liquid and Submicron Physics project to Subactivity HK 01 01.

Life Sciences Research and Biomedical Applications (HK 01). These subactivities include basic life

sciences research programs that support the specific technology-oriented activities in the GK programs. Research efforts in carcinogenesis and mutagenesis contribute to the development, validation, and improvement of systems for testing new biological hazards. To answer problems relating to toxicological effects, we are undertaking programs aimed at acquiring the knowledge necessary for determining the identification, dosage, and source of the materials involved. The biomedical applications program includes efforts to capitalize on the unique probing abilities of stable and radioactive isotopes by using them to detect subtle pathological changes that may be harbingers of serious diseases in humans.

For FY 1980, we have requested increased funding for the General Life Science program (Subactivity HK 01 01). This increase will be necessary not only to provide a cost-of-living escalation but also to facilitate expansion of efforts in the following tasks: Carcinogenic Screening with a Human Cell Line; Nucleic Acids in Pathogenesis; Effects and Uses of Chromosome Aberrations, which will be transferred from GK 01 02 02 0; Photophysics of Macromolecules; Studies on Mutation Induction; Liquid and Submicron Physics, which will be transferred from GK 01 02 04 2; Protein Chemistry; Physiochemical Properties of Chemical Pollutants, Biologically Active Molecules, and Related Structures, which will be transferred from GK 01 02 04 3; and Gene Expression in Carcinogenesis. Increases in these projects will be partially offset by the discontinuation of the Carcinogenesis and Gene Expression task. A cost-of-living escalation has also been requested for FY 1981.

During this planning period, programs in Biomedical Applications (Subactivity HK 01 02) will continue developing and testing new radiopharmaceuticals, particularly ones for use in imaging the heart and brain. One such agent developed by ORNL—a heart-imaging agent that uses an isotope of tin—has generated considerable interest in the medical community, and we shall continue its development through clinical tests performed in conjunction with other organizations.

In addition, we shall apply our expertise with radionuclides to examining the environmental fate and effects of energy-related materials such as arsenic and selenium. This effort will include radioactively tagging these materials to determine their distribution in biological and environmental systems. We shall also investigate the feasibility of radiolabeling certain organic compounds of interest in energy production in order to determine their fate in various systems.

Major Changes

As indicated in these detailed descriptions, the emphasis in the life sciences work at ORNL is changing from nuclear to nonnuclear areas; we expect this change to continue during this planning period but at a considerably slower rate. Reflected in this change is the increase in Laboratory research programs on the environmental and health impacts of coal utilization and conversion technologies.

In addition, several important institutional changes in the biomedical and environmental program should be noted. First, the Laboratory is currently selecting a new director for the Biology Division; this change should cause no problems in this important life sciences area. Second, the responsibilities of the Office of Environmental Policy Analysis have been incorporated into the newly established Office of Integrated Assessments and Policy Analysis within the Health and Safety Research Division. This move, while maintaining adequate visibility for these programs, will enable the effective integration of the Policy Analysis activities with the line functions of the life sciences program.

Major Issues

During this planning period, ORNL's life sciences program will face several major problems. One concern is the continued reduction in funding for basic life sciences R&D, including both biological and environmental research. This absolute decrease coincides with an increase in emphasis on the basic life sciences research associated with nonnuclear technology development. In addition, some support for this area is being redirected toward applied research efforts supporting site-specific evaluations of synthetic fossil fuel technologies in the demonstration phase. The combined effect of these trends is to weaken ORNL's ability to investigate the basic life sciences aspects of both the nonnuclear and nuclear technologies: some growth in these programs must be allowed if the knowledge and understanding necessary to assess new coal conversion and other fossil energy technologies are to be obtained while efforts on the more conventional technologies, both nuclear and nonnuclear, are continued.

Another concern involves work performed for other federal agencies as a part of the ORNL integrated life sciences programs (discussed later in this chapter under "Non-DOE Work"). For ORNL to maintain its basic science capabilities as well as overall institutional and program flexibility, the programs sponsored by Environment (EV) must be

supported by complementary activities funded by interagency agreements and grants from other federal organizations. Because these programs contribute to the solution of energy-related problems, they offer significant benefit to DOE. Currently, about one-third of the life sciences program is supported by federal agencies other than DOE. Moreover, in the area of radiation research—one in which we anticipate reawakened emphasis as a result of recent inquiries and public concerns—a major review of DOE-supported research is currently under way, which may result in some of this work being shifted to other federal agencies. Considering this, our desire to maintain flexibility, and the need to pursue Work-for-Others programs that complement DOE programs, ORNL's ability in this area must be strengthened.

Decontamination and Decommissioning (AG 70)

Technical Thrust

This program supports DOE efforts to provide for the safe management and disposal of its (and its predecessor agencies') surplus radioactively contaminated facilities and sites. Laboratory activities include (1) planning and scheduling disposition and stabilization and (2) monitoring selected sites to determine baseline conditions as well as conditions after decontamination and decommissioning activities. Note that these tasks do not involve ORNL in any actual cleanup work. Our role is limited to determining the initial level and location of contamination and making recommendations to DOE regarding the certification of the radiological status of the site after cleanup.

Major Changes

Increased funding will be required for ORNL's FY 1980 efforts.[9] Three new projects, (1) Planning for Disposition of Surplus Facilities—Excluding Reactors, Fission Products Development Laboratory, and Gunite Tanks; (2) Fission Products Development Laboratory Decommissioning; and (3) Extraction of Potentially Hazardous Radionuclides from Uranium Ores and/or Tailings, were initiated in FY 1979, and we propose significantly increased effort for all of them in FY 1980. The Radiological Survey of Formerly Used Manhattan Engineering District/Atomic Energy Commission (MED/AEC) Sites project will also be expanded, and a new task, Surveillance of Surplus, Pre-October 1976 Facilities, will be initiated. The increase of 1.6 FTEs in Work Package Proposal and Assignment System (WPAS) No. 600036 and smaller increases on several other tasks will also contribute to the need for additional funding. A funding increase will be required and has been requested for the Fission Products Development Laboratory Decommissioning task in FY 1981. However, despite this possible FY 1981 expansion and the FY 1980 increase, funding for most of this activity should decrease during the remainder of the planning period.

[9]Since the preparation of this document, responsibility for some of the work in this area has been transferred to the Office of Nuclear Waste Management. Funding of $0.8 million in FY 1980, which may increase in later years, remains with ASEV.

Lead Missions for the Assistant Secretary for the Environment

Environmental Research for Gasifiers in Industry and H-Coal (current role). This mission's objective is to develop a data base enabling determination of the environmental and health acceptability of synthetic fossil fuel technologies. The program focuses primarily on coal conversion technologies (i.e., gasification and liquefaction) but also includes, in our comparative study activities, some chemical characterization and biological testing of shale oil products and natural crudes. The current emphasis of our site-specific coal conversion research is on studies of the low-Btu gasifiers at UMD and Pike County, Kentucky, and of the H-Coal liquefaction process. The latter study involves initial tests of products from the process development unit at Trenton, New Jersey, and program implementation for the pilot plant at Catlettsburg, Kentucky. We are able to support DOE initiatives in either of these coal conversion technologies.

Program activities include chemical and physical characterization and monitoring of synthetic fossil fuel products and effluents; study of the biological and health effects of these materials and of the environmental transport, fate, and effects of pollutants; and development of integrated assessments. The results of these and related studies are applied to health and environmental monitoring and testing activities in the Gasifiers in Industry Program (i.e., UMD and Pike County, Kentucky) and in coal liquefaction projects (i.e., H-Coal, Catlettsburg, Kentucky).

The program is a response to the mandates of Congress and also answers the Administration's concern for identifying and mitigating potential health and environmental effects in fossil fuel applications and thereby enabling safe acceleration of our use of U.S. fossil energy resources.

Major milestones include program development and implementation. Implementation of the Environmental and Health Monitoring and Testing Program at UMD began in FY 1978. In FY 1979, program plans were completed for the Pike County and H-Coal projects, and implementation of these anticipated three-year projects will begin in FY 1980. If requested, program development for other liquefaction projects, such as the SRC demonstrations, can also begin in FY 1980. Program plans for the SRC projects currently include only one specific activity: staff of the ORNL Chemical Technology Division, at the request of ECT/EV, will collect substantial volumes of aqueous effluents from the SRC-I pilot plant at Wilsonville, Alabama, for testing in the ORNL bioreactor.

Experience gained through the Life Sciences Synthetic Fuels Program, which has been functional at ORNL since 1975 and is discussed in previous institutional plans, has well qualified us for the lead laboratory role. Assignment of lead responsibility to ORNL was proposed to the acting ASEV during FY 1978, and the role is now described as an approved function. Components of this function are identified in the reporting requirements for the site- and process-specific studies listed by EV in September 1979 as UMD gasifier, Pike County gasifier, H-Coal, Coal Liquids Evaluation, and End Use (Paraho-Navy). The Laboratory is responsible for identifying problem areas and support requirements; for directing onsite and offsite programs, including subcontractor activities, in cooperation with DOE Headquarters' Program Office and Operations Office; and for coordinating ORNL work with related fossil energy activities being performed by other DOE contractors.

The Oak Ridge Operations Office (ORO) provides the Laboratory with implementation-level policy, strategy, and programmatic direction in accordance with approved plans, schedules, and costs. Additional support provided by ORO includes assistance in the development of the national management plan and the national program plan, program guidance to other participating field units, technical staff input to the program, and full services support in all business management areas. ORO also directs ORNL's performance in executing technical and financial aspects of the program and makes recommendations to DOE Headquarters on corrective changes in management, program scope, and funding.

Program responsibilities require that ORNL interact closely not only with ORO but with numerous other organizations as well. The Laboratory manages major subcontracts for the University of Minnesota that provide monitoring and sampling assistance at the UMD project. These subcontracts, which will eventually constitute at least 25% of the total project effort, secure support from experienced vendors of sampling protocols and equipment. Future subcontracts in the implementation of other applied field projects (i.e., use of the Pikeville College staff in the Pikeville, Kentucky, project) are expected to account for 40 to 70% of the total costs of the individual projects.

Technology transfer is effected in several ways. Information gained through the field projects is transferred directly to university and state and local government participants. Similarly, the involvement of both the Environmental Protection Agency (EPA) and the National Institute for Occupational Safety and Health (NIOSH) in the UMD project ensures that project-derived data are quickly accessible. Study results are also transferred through various scientific and industry-oriented symposia and workshops (e.g., the Symposium on Potential Health and Environmental Effects of Synthetic Fossil Fuel Technologies, September 25–28, 1978, Gatlinburg, Tennessee, which was sponsored by DOE's environmental programs and hosted by ORNL).

This program is supported through the following WPAS numbers: GK0101012—000688; GK0101031—3078; GK0101033—01684C, 01684E, 01684F, 01684G, 01684H, 01684I; GK0101041—800060, 800158, 800300; GK0101052—600114; GK01020201—000145, 000146, 000147, 001562, 001700, 002360, 002361, 004086, 004087, 004089, 002587, 002590; GK0102022—000173, 000174, 000181, 000184, 000237, 001474, 001476, 001566, 001569, 001570, 002375, 002559; GK0102023—002373, 000154, 000183, 002374, 002526, 004090; GK0102031—002382, 003079; GK0102032—000680, 001693; GK0102033—001711; GK0102041—001603; GK0102043—001607, 001707, 001710, 001711, 001722, 002548, 002613, 002943; and HK0101000—000169, 000283, 000286, 001588, 001560, 001701.

Summary of resources – Environmental Research for Gasifiers in Industry and H-Coal[a]

	'79	'80	'81	'82	'83	'84	'85
Operating cost	6.3	7.2	7.6	7.2	6.6	5.9	5.9
Capital equipment	1.1	0.3	0.5	0.3	0.3	0.3	0.3
Subcontracting and procurement	0.9	2.4	2.4	1.9	0.5	0.1	0.1
Direct FTE	82	88	93	88	81	72	72

[a]Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. Personnel numbers are in full-time equivalent (FTE) person-years. The decline after FY 1981 reflects the completion of current projects. Dollar levels may vary depending on actual facility operations and on DOE requests to investigate other facilities. Because of the current interest in developing synthetic fuels technologies, effort in this activity should not decrease in the future.

Ecosystem Modeling for Regional Environmental Resource Analysis (current role). The objective of this program is to develop models that can be applied to regional environmental and energy resource problems. Technical simulation models are being developed to analyze energy resource utilization, environmental risks, and ecological benefit-cost ratios and to devise strategic scenarios delineating optimum mixtures of energy technologies (fossil, nuclear, solar, geothermal, etc.) for various regions of the United States. In response to Administration policy, the program seeks to maximize the use of domestic coal reserves while maintaining or enhancing environmental quality.

During this planning period, we foresee the achievement of two major milestones. The projects that will be completed are an ecological evaluation of identified potential U.S. wilderness areas, by early 1980, and, during the same year, the conceptualization of a regional ecological model.

The Laboratory is responsible for technical direction of the program, which includes coordinating other contractors' activities and defining program requirements. ORO provides ORNL with implementation-level policy, strategy, and programmatic direction in accordance with approved plans, schedules, and costs. Its other responsibilities include (1) assisting in the development of both the national management plan and the national program plan; (2) providing program guidance to other participating field units; and (3) directing ORNL's performance in executing technical and financial aspects of the program. It also makes recommendations to DOE Headquarters on corrective changes in management, program scope, and funding and provides technical staff input to the program and full services support in all business management areas. The assignment of lead laboratory role to ORNL was proposed in the last *Institutional Plan* and has not been disapproved.

In addition to ORO, the Laboratory interacts extensively with various other organizations. In our role in managing subcontracts, we work closely with several universities; major subcontracts are to the University of Tennessee, Knoxville, for systems analysis (7% of total effort); the University of Wyoming, Laramie, for resource analysis (5%); and the University of Oklahoma, the University of Wisconsin, and Utah State University, for regional ecology studies (5%). The Laboratory is also required to maintain technical coordination between this mission and related DOE programs, including the Regional Studies Program; all coal (and other fossil), uranium, geothermal, and hydroelectric development programs; Fuels from Biomass; and Carbon Dioxide Effects.

The following WPASs cover this program: Systems Ecology, No. 00607; Eastern Deciduous Forest Biome, No. 00611; Spatial Data System; Regional Studies Program, No. 01684; RARE II, No. 03214; Fuels from Biomass; Forest Island Dynamics [National Science Foundation (NSF)]; Numeric Information (EPA); DOE Data Resources for Global CO_2 [New or Expanded Work (NOEW)]; DOE Remote Sensing for Global Carbon in Biosphere (NOEW); and Regional Ecology of Wetlands (NOEW).

Summary of resources – Ecosystem Modeling for Regional Environmental Resource Analysis[a]

	'79	'80	'81	'82	'83	'84	'85
Operating cost	1.3	1.4	1.6	1.7	1.8	1.9	2.0
Capital equipment	0.1	0.1	0.1	0.1	0.2	0.2	0.2
Subcontracting and procurement	0.1	0.1	0.2	0.2	0.2	0.2	0.2
Direct FTE	17	18	18	18	18	18	18

[a]Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. Personnel numbers are in full-time equivalent (FTE) person-years.

Integrated Regional Assessments for Regions 4 and 6 (current role). The Office of Technology Impacts has initiated several assessments of the

potential nationwide effects of the National Energy Plan (NEP) and related national policies. ORNL has been given lead laboratory responsibility in this mission, formerly entitled "Policy Analysis," with respect to integrated nuclear assessments, siting projections, water availability studies, and regional energy and economic disaggregations. The basis for this lead role assignment is OTI Program Guidance for FY 1978 and FY 1979.

Major milestones include an assessment of phosphate mining, September 1979; reports on selected EDPs, September 1979; draft reports on energy and economic disaggregation, siting, and water availability, September 1979; final reports on energy and economic disaggregation, siting, and water availability, September 1979; final NEP national assessments, September 1979; draft regional assessments, December 1980; and various regional and technology assessments, 1981 through 1985.

ORO is responsible for providing ORNL with implementation-level policy, strategy, and programmatic direction in accordance with approved plans, schedules, and costs. It lends additional support to the project by providing (1) assistance in the development of the national management plan and the national program plan; (2) program guidance to other participating field units; (3) technical staff input to the program, and (4) full services support in all business management areas. ORO also directs ORNL's performance in executing technical and financial aspects of the program and makes recommendations to DOE Headquarters on corrective changes in management, program scope, and funding.

Additional ORNL responsibilities in the assessments and policy analysis area include the management of subcontracts, which for this mission are minor personal-service consulting agreements, and technical coordination of this activity with related DOE programs. The Laboratory itself conducts several related programs, including regional studies activities and additional OTI-sponsored programs on environmental policy analysis, technology assessments, and environmental impacts. Other DOE contractors have similar, integrally related programs for which the results of this mission provide direct input. Additional related programs include surveys of inactive uranium mills and formerly used MED and AEC sites, environmental assessment of advanced breeder fuels, model evaluation of breeder reactor activity releases, assessment of radiation doses resulting from releases of ^{222}Rn and ^{226}Ra from uranium mining and milling activities, and development of "as-low-as-reasonably-achievable" guides for the nuclear fuel cycle.

To enable technology transfer, program results must be made readily available. Selected methodologies and data bases are transferred to DOE. Through publications, conferences, workshops, and other media, information and research results are disseminated to federal, state, regional, and local organizations and users groups.

This program is covered by the following WPASs: OTI Policy Analysis Division, No. 002975; Technology Assessments Division, No. 002976; Regional Assessments Division, No. 001684; and Environmental Impacts Division, No. 002224.

Summary of resources – Integrated Regional Assessments for Regions 4 and 6[a]

	'79	'80	'81	'82	'83	'84	'85
Operating cost	1.5	1.5	1.6	1.6	1.6	1.6	1.6
Direct FTE	7	7	8	8	8	8	8

[a]Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. Personnel numbers are in full-time equivalent (FTE) person-years.

Environmental Impact Assessment for Nuclear Fuel Cycle and Waste Management (proposed role). The objective of the proposed program is to provide overall management responsibility for the National Environmental Policy Act (NEPA) activities required to support DOE programs in the nuclear fuel cycle and waste management areas. Program goals reflect the Administration policy of developing safe and environmentally acceptable energy sources.

ORNL will be responsible for technical management of the environmental impact assessments and statements required by NEPA for DOE nuclear fuel cycle activities. The role will involve defining requirements and coordinating in-house activities and the work of other contractors, including universities, private consultants, and other national laboratories. Major ORNL milestones will be (1) to develop and coordinate activities, (2) to procure major subcontracts, (3) to produce NEPA documents according to the schedule developed in the first milestone, and (4) to coordinate mission activities with existing DOE programs in waste management.

ORO will provide the Laboratory with implementation-level policy, strategy, and programmatic direction in accordance with approved plans, schedules, and costs. Its other responsibilities will include (1) assisting in the development of the national management plan and the national program plan, (2) providing program guidance to other participating field units, and (3) providing technical

staff input to the program and full services support in all business management areas. Furthermore, it will direct ORNL's performance in executing technical and financial aspects of the program and make recommendations to DOE Headquarters on corrective changes in management, program scope, and funding.

Further interaction on the part of ORNL will be required in managing subcontracts, coordinating mission activities with related programs, and effecting technology transfer. For this program, subcontracted support will come from universities, private consulting firms, and other national laboratories. We are currently involved in several related programs that provide major assistance to DOE and the Nuclear Regulatory Commission (NRC) in areas pertaining to the nuclear fuel cycle and could readily coordinate these programs with the proposed mission; these areas include environmental assessment of mining and milling, fuel fabrication, reactor construction and operation, and waste handling. Finally, technology transfer will be easily facilitated as a result of the fact that part of our existing effort in environmental assessments includes extensive interaction with universities, state and local governments, and private industry.

This program is covered by the following WPASs: Environmental Statement Project—Reactor, No. B0001; Environmental Statement Project—Fuel Cycle Facilities, No. B0279; and Reactor Radwaste Generic Study, No. B0171.

Summary of resources – Environmental Impact Assessment for Nuclear Fuel Cycle and Waste Management[a]

	'79	'80	'81	'82	'83	'84	'85
Operating cost	3.0	3.2	3.4	3.9	4.1	4.2	4.2
Capital equipment	0.2	*	*	*	*	*	*
Subcontracting and procurement	1.1	1.2	1.3	1.5	1.6	1.7	1.7
Direct FTE	21	21	21	24	25	25	25

[a]Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. An asterisk indicates funding of less than $50,000. Personnel numbers are in full-time equivalent (FTE) person-years.

Nonnuclear Solid Waste Technology (proposed role). This program's objective is to develop environmentally sound techniques for managing the solid wastes produced by our society, including those from nonnuclear energy production and from manufacturing and municipal activities. This program will provide a focal point for the various ongoing programs studying solid waste management and will thereby minimize duplication of effort. During the past few years, considerable attention has been given to shallow land burial of nuclear wastes, and much of what is being learned is directly applicable to nonnuclear wastes. Because of increasing emphasis on nonnuclear energy production and, in particular, on expanding the role of coal as an energy source, proper management of the wastes produced by these technologies will increase as a public concern. As this program will emphasize, waste management includes not only disposal of wastes but also the recovery of reusable resources.

A draft of the national research plan was completed by ORNL in the first quarter of FY 1979 and presented to DOE. Major milestones include (1) designing environmentally and economically acceptable waste disposal procedures for coal conversion facilities and implementing them at demonstration sites, (2) screening solid wastes in accordance with RCRA testing regimes, and (3) establishing generic research that addresses disposal alternatives and emphasizes resource recovery management.

As delineated in the research plan, the Laboratory will conduct a long-term basic science program investigating the various technological aspects of nonnuclear solid waste management that will emphasize recovery of resources as well as the economical and environmentally sound disposal of solid wastes generated in energy-producing technologies. To avoid duplication within DOE-funded programs, ORNL will provide DOE with a unified work plan for the solid waste R&D activities at all of its national multiprogram laboratories and, subsequently, as lead laboratory, will manage these activities. The DOE laboratories conducting solid waste R&D include Los Alamos Scientific Laboratory, Scientific Research Laboratory, Hanford Engineering Development Laboratory, Idaho National Engineering Laboratory, Battelle Pacific Northwest Laboratories, Rockwell-Hanford, Rocky Flats, and Sandia Laboratories. In addition, we will coordinate the laboratories' programs with those of research agencies outside DOE, such as EPA and the Electric Power Research Institute (EPRI), that fund and conduct solid waste research. This assignment was proposed, under the title "Shallow Land Burial (Nonnuclear)," in the last *Institutional Plan* and has not been disapproved.

ORO will provide the Laboratory with implementation-level policy, strategy, and programmatic direction in accordance with approved plans, schedules, and costs. Additional support provided by

ORO will include assistance in the development of the national management plan and the national program plan, program guidance to other participating field units, technical staff input to the program, and full services support in all business management areas. ORO will also direct ORNL's performance in executing technical and financial aspects of the program and make recommendations to DOE Headquarters on corrective changes in management, program scope, and funding.

Numerous DOE programs that are not directed specifically at researching solid waste disposal pertain to this program, and ORNL will be responsible for applying results of these programs to the solid waste mission. Included are several programs in low-level nuclear waste management (activity migration in soils, waste volume reduction, etc.), several under the Director of Energy Research in the coal program (resource recovery from fly-ash and coal conversion residues, ash disposal, etc.), and several under ASEV in areas such as environmental control R&D, environmental monitoring, and the development of environmental data bases.

A primary goal of the program will be to transfer technology on shallow land burial to industries and federal, state, and local governments. This will be facilitated through subcontracts, which will be managed by ORNL, to universities, commercial firms, and industry consultants.

The following list is of the WPASs that are either fully or partially on shallow land burial and resource recovery (some of these also appear in the lead mission proposals for low-level waste management, fossil energy materials technology, and residential and commercial energy conservation): Nos. 00083, 00006, OH1024, 0003, 00076, ON 4909A, ON 5109A, ON 7309A, ON 5709A, ON 0109A, ON 67309A, and ON 7509A.

Summary of resources – Nonnuclear Solid Waste Technology[a]

	'79	'80	'81	'82	'83	'84	'85
Operating cost	1.3	3.4	3.7	4.6	4.8	5.1	5.2
Capital equipment	0.2	1.0	1.0	1.0	1.0	1.1	1.1
Subcontracting and procurement	0.1	0.5	0.7	1.5	1.6	1.7	1.8
Direct FTE	17	25	27	28	29	30	30

[a]Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. Personnel numbers are in full-time equivalent (FTE) person-years.

Assistant Secretary for Conservation and Solar Applications

Conservation and solar work for DOE is funded by both Conservation and Solar Applications (CS) and Energy Technology (ET). In this section, we discuss the work that ORNL conducts and manages for CS. The Laboratory's programs for CS are expected to grow during the early part of this planning period; however, following increases between FY 1979 and FY 1982, little additional growth is projected. Much of ORNL's modest solar energy program, which in FY 1979 constituted less than 1.5% of the Laboratory budget and which is not expected to exceed 2% in the future, was undertaken at DOE's request. Work for CS accounts for about one-fifth of our total solar program and complements the related work for ET.

Conservation

Technical Thrust

Residential/Commercial (C3). ORNL now manages major portions of DOE's programs on energy conservation in residential and commercial buildings. Program activities include developing energy-efficient heat pumps and appliances, improved insulation materials and thermal envelopes, innovative concepts in building structures, and the Annual Cycle Energy System (ACES). In each of these areas, ORNL works with the appropriate segment of the manufacturing or construction industry to develop, evaluate, and demonstrate promising new concepts. To ensure rapid commercialization, a large portion of the development work is subcontracted to potential manufacturers. The Laboratory's role includes assisting DOE with program planning, managing development subcontracts, and performing selected research activities in-house.

In the ANFLOW (anaerobic, upflow, packed-bed bioreactor) program, an anaerobic process is being developed for treating municipal waste; the process greatly reduces energy consumption and also produces methane. A pilot demonstration has been completed, and design of a scaled-up commercial-size plant is beginning.

In a new program begun in FY 1979, the Residential Conservation Service Program, ORNL is assisting DOE in developing technical information relating to retrofitting homes with conservation and solar measures. In 1980, the Residential Conservation Service will be implemented by the utilities. The current emphasis is on providing information to

support the required rulemaking process and on developing technical support services for states and utilities. In future years, we will perform research on additional technical issues.

Ongoing efforts also include data collection and analysis and the formulation and use of energy demand models. The results of these activities are widely used in regulatory policy analysis and in R&D program planning.

Industrial Energy Conservation (C4). The selection and demonstration of reliable materials for use in high-temperature processes and in recuperators for waste heat recovery are vital to industrial conservation. In ORNL's industrial conservation program, the major emphasis is on developing a data base, based on in-house testing and post-test analysis of industrial demonstrations, that will allow reliable materials selection. Potential applications include ceramic and metallic materials for recuperators and cogeneration systems, industrial insulations, and refractories for industrial furnaces. In our furnace combustor tests, we are identifying detrimental reactions between alternative fuels and commercial refractories; this information will provide guidance for the use of heavy oils and coal-derived fuel in process-heat applications. Relative to this effort, the Laboratory is taking the lead in the development of consensus standards and test methods for high-temperature insulation.

Additional tasks proposed for this planning period include developing and demonstrating ceramic coating systems that will improve the lifetime and effectiveness of refractory fiber insulation. Also, to provide input for alternative combustor designs, we will establish a coal-fired materials test facility in which refractory materials performance, flame retardation properties, and coal combustor environmental releases can be determined.

Concepts for recovering valuable resource materials from wastes have far-reaching conservation potential. A proposed ORNL program will be aimed initially at recovering metallic compounds from ash. In other activities, we (1) are continuing to develop and analyze detailed energy use and conservation statistics for the industrial sector; (2) have proposed that ORNL's ANFLOW process, which has potential application to many types of industrial waste, be developed and demonstrated for several specific industries; and (3) are providing technical assistance to DOE in related industrial conservation programs.

Transport (C5). To provide the reliable data on transportation energy use needed for policy decisions, ORNL, which has been selected by the director of DOE's Office of Transportation Programs as the primary laboratory for transportation analysis, will continue to develop and analyze a comprehensive transportation data base. The objective of this effort is to develop a sector-wide model. Additional efforts in this program include a proposed project for developing the chemical knowledge needed for the design of improved coal-slurry transport systems. Also, ORNL will participate in the Hybrid and Electric Vehicle Program by purchasing five electric vehicles and monitoring their performance.

Major Changes

With DOE's concurrence, we will participate more actively in the development of new materials as well as in the technical planning and review of industrial conservation demonstration programs.

Major Results or Milestones

Field demonstrations of a high-efficiency refrigerator-freezer and an electric-heat-pump water heater will be completed in 1980, as will development of an improved motor-compressor. To continue the effort begun by ongoing tests and evaluations of the interactions of residual oils and refractories, we have proposed that tests of refractories in contact with coal-oil slurries and synfuels be started in FY 1980. A large-scale demonstration of the ANFLOW process will begin in FY 1980; performance will be monitored in FY 1981; and results, including recommended designs for commercial systems, will be published in FY 1982.

Solar

Technical Thrust

Solar Applications (BD 01). At DOE's request, we have assumed responsibility for the technical monitoring of the Agricultural Process Heat Program included in this activity. ORNL provides assistance to both DOE and the Department of Agriculture (DA), which manages the agricultural portions of the program, by independently evaluating each project proposed to DA, monitoring the progress of the funded projects, and reporting that progress to DA and DOE. Another program is developing passive solar heating and cooling techniques for humid climates; this effort complements the innovative housing work being done in the conservation programs. As an initial task in this program, we are developing reflective insulating blinds for use in passively heated buildings. This

program also includes a study of the annual energy storage in soil adjacent to earth-covered structures.

Solar Commercialization Support (BD 02). With other DOE offices, CS supports the development of detailed engineering-economic computer models that simulate residential and commercial energy use. By enabling short- and long-run analyses of alternative policies and new technologies, these models will aid in evaluating the potential for commercialization of solar applications.

Major Changes

For this planning period, we seek an expansion of our experimental work in passive solar heating and cooling. This work will be given priority over technical monitoring activities.

Lead Mission for the Assistant Secretary for Conservation and Solar Applications

Residential and Commercial Conservation in Buildings and Appliances (current role). Recently, CS has assigned to ORNL lead missions in Annual Cycle Energy Systems, building energy systems, thermal insulation, appliances and heat pumps, and the Residential Conservation Service. The goal of this program is to develop methods for reducing the amount of energy required for heating, ventilating, and air-conditioning (HVAC) systems and appliances for residential and commercial buildings. Projects include a comprehensive heat pump program, the objective of which is to provide both near- and long-term conservation methods, and the demonstration of an innovative residential heating and cooling system. The program also encompasses the development of energy-saving appliances and structures, a national technical plan for insulation materials and standards as well as for the Residential Conservation Service, and models for forecasting future energy needs for residential and commercial buildings.

The program's major milestones for this planning period include achievements in the projects that are developing heat pumps with improved performance and reliability, energy-efficient appliances, thermal insulation standards, and innovative structures and HVAC systems. For the heat pump program, two milestones have been established—to introduce advanced electric heat pumps that are 20% more efficient than current models by the mid-1980s and to produce gas-fired heat pumps with twice the heating season efficiency of today's gas furnaces by the late 1980s. A prototype electric-heat-pump water heater that consumes only one-half the energy of a conventional water heater has been designed, built, and tested; field testing of this unit should be completed in FY 1980. Prototype models of other improved appliances, including a refrigerator-freezer, motor-compressor, and gas-fired water heater, have also shown promise in initial testing.

As program lead, the Laboratory performs in-house R&D, conducts program planning, selects subcontractors, and supervises subcontracts and demonstrations. The Oak Ridge Operations Office (ORO) provides the Laboratory with implementation-level policy, strategy, and programmatic direction in accordance with approved plans, schedules, and costs. Additional support provided by ORO includes assistance in the development of the national management plan and the national program plan, program guidance to other participating field units, technical staff input to the program, and full services support in all business management areas. ORO also directs ORNL's performance in executing technical and financial aspects of the program and makes recommendations to DOE Headquarters on corrective changes in management, program scope, and funding.

To ensure proper supervision of subcontracted work, ORNL assumes management responsibility only for subcontracts in areas of in-house expertise. At least 15% of the work in Laboratory-managed programs is performed in-house. The major subcontracts for this mission have been given to (1) Honeywell, to determine the economic competitiveness of the ACES concept with conventional heating and cooling systems; (2) the University of North Dakota, to develop a split-evaporator ice-maker heat pump; (3) R. G. Werden, for consultation on the ACES concept; (4) Energy Utilization Systems, Inc., to develop and test a high-efficiency electric water heater; (5) Columbus Products, to develop and demonstrate prototype motor-compressors for refrigerator-freezers and room air conditioners; and (6) the National Bureau of Standards, for testing and evaluation of various residential and commercial applications.

Another responsibility is to coordinate these activities with related programs, which include DOE's Low-Temperature Thermal Energy Storage program.

The ANFLOW system being developed at ORNL is based on the anaerobic filter principle. The system has potential for conserving up to 70% of the energy required for conventional wastewater treatment systems while recovering usable methane-rich gas. A

major advantage is that the quantity of sludge produced in the system is less than that produced in the standard system.

To expedite application and commercialization of new technology, industrial and architect-engineering firms are used as subcontractors.

This program is covered by the following Work Package Proposal and Assignment System (WPAS) numbers: Annual Cycle Energy System Implementation, C3 01 01 00 0; Innovative Structures, C3 01 01 00 0; Heat Pump Research and Development, C3 01 04 00 0; Management of Residential and Commercial Appliance Program, C3 01 04 00 0; Residential and Commercial Heat Pump Program Management, C3 01 04 00 0; Building Thermal Envelopes and Insulating Materials, C3 01 02 00 0; Thermal Insulating Materials, C3 01 04 00 0; Engineering-Economic Models of Energy Use, C3 01 01 00 0; and Residential Energy Service Program, C3 01 03 01 3.

Summary of resources – Residential and Commercial Conservation in Buildings and Appliances[a]

	'79	'80	'81	'82	'83	'84	'85
Operating cost	10.2	13.9	13.5	13.5	13.5	13.5	13.5
Capital equipment	0.4	0.5	0.2	0.2	0.2	0.2	0.2
Subcontracting and procurement	7.9	11.0	10.5	10.4	10.4	10.4	10.4
Direct FTE	31	37	37	38	38	38	38

[a]Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. Personnel numbers are in full-time equivalent (FTE) person-years.

Assistant Secretary for Defense Programs

Special (Nuclear) Materials Production (JM 03)

Technical Thrust

This activity involves ORNL in two important tasks. As the ^{233}U National Repository for DOE, we operate and maintain equipment for receiving, storing, processing (by solvent extraction and ion exchange), converting (from nitrate solution to oxide powder), and shipping ^{233}U in accordance with safety requirements. ORNL provides a significant service in managing scrap ^{233}U nuclear materials in a cost-effective manner to reduce new materials production requirements, to minimize storage costs, and to conserve materials and energy. In the second task, we are designing, fabricating, purchasing, and installing equipment for converting 1047 kg of uranium solution to an inert solid for storage. In its present form and location, this uranium (10% ^{233}U and 75% ^{235}U) poses a hazard because of its fissile content and high-energy ^{232}U daughter of ^{233}U.

Major Changes

Conversion of the uranium solution to a solid that complies with dry storage requirements, which will occur in FY 1983 and FY 1984, will require a sizable commitment of resources through FY 1984.

Nuclear Materials Security and Safeguards (JM 04)

Technical Thrust

In the Laboratory's single task included in this activity, Microsampling Analytical Techniques, we are developing improved methodology for isotopic analysis, which is the foundation of nuclear safeguards. ORNL's ongoing R&D seeks improvement of the mass spectrometric isotopic analyses of elements of interest in safeguards (i.e., uranium, plutonium, and thorium). Included in this effort is exploration of the resin-bead sample-loading technique and development of methods that will enhance isotope ratio measurements through increased reliability and precision and reduction in sample size. Experimental demonstrations of the value of the resin-bead methodology have begun in cooperation with both the International Atomic Energy Agency (IAEA) and Tokai, Japan.

Major Changes

During this planning period, the program effort will be expanded to include an assessment of the applicability of a quadrupole mass spectrometer to safeguards; it is proposed for use as a portable monitoring device.

Assistant Secretary for Resource Applications

Uranium Resource Assessment (BG 20)

In its task work in this activity, ORNL is developing new or improved processes for extracting

uranium from the waste streams of the manufacturing processes for phosphate fertilizers and is providing computer-based management of survey data and other information support services for DOE's Grand Junction Office. Several companies are developing new phosphoric acid (hemihydrate) processes that, while more efficient and less energy intensive than the current 30% P_2O_5 acid processes, produce acids that may be too concentrated to be compatible with any of the known uranium recovery processes. Consequently, we will perform a comprehensive investigation to find extractants that can be used to recover uranium from the more concentrated, 40 to 50% P_2O_5 phosphoric acids of the future.

Small Hydroelectric Development (BH 01)

Described as a new initiative in last year's *Institutional Plan,* ORNL's low-head hydroelectric research program is now listed as "new work" because the necessary resources were approved (within personnel planning levels) by the Assistant Secretary for Energy Technology during the DOE onsite review. DOE is encouraging small hydroelectric technology development by funding feasibility studies and demonstrations, in both the public and private sectors, of the redevelopment of existing dams with a potential capacity of 15 MW or less. The Laboratory began research on the environmental issues related to this redevelopment in 1978 through the preparation of an environmental assessment of the DOE Hydropower Development Program under Resource Applications. Subsequent to this initial assessment, in October 1978, we prepared and began implementing an Environmental Subprogram Plan that identifies and analyzes the potential environmental constraints to the small hydroelectric technology development; DOE will consider these constraints as specific development plans are prepared.

ORNL is currently providing DOE with in-depth analysis of several issues that have been identified as possible generic constraints to the redevelopment effort; these are fish passage, turbine mortality, water level fluctuation, and dredging. During FY 1980 and FY 1981, we will examine extant water quality data and evaluate the extent to which small dam systems modify water quality. At DOE's request, we will also conduct specific research at DOE and other demonstration sites that will address environmental issues of generic interest to the program. Research will begin at DOE sites in FY 1980 and at others in FY 1981. Throughout the planning period, ORNL will continue to provide DOE with technical assistance.

Federal Leasing (BK 02)

In addition to the new work described in the previous section, ORNL has initiated research in which methods for assessing potential conflicts between wilderness preservation and energy resource development will be developed and applied. Other issues common to resource analysis, regional assessment, impact assessment, and economic analysis are also being studied.

Lead Mission for the Assistant Secretary for Resource Applications

Environmental Analysis and Research for Small Hydroelectric Technology (current role). The objective of this program is to identify, analyze, and research possible environmental constraints to the redevelopment of existing dams with a potential hydroelectric generation capacity of 15 MW or less. Program efforts include (1) analysis of available literature and data on hydroelectric impacts on aquatic systems pertaining to water level fluctuation, fish passage around dams, turbine mortality of aquatic biota, and dredging; (2) analysis of the water quality data available for a large number of U.S. dam systems in order to quantify trends in water quality above and below hydroelectric facilities; (3) environmental research at DOE and other demonstration sites that will address issues of generic interest to technology development; and (4) maintenance of a core group of environmental scientists with technical expertise in environmental issues related to small hydroelectric technology that will provide necessary technical assistance to DOE. This program will help fulfill the goal established in the National Energy Plan of developing an environmentally acceptable hydroelectric technology.

As lead laboratory, ORNL's responsibilities include identifying environmental issues and research and analysis requirements, directing and executing onsite and offsite programs in cooperation with the DOE Hydroelectric Power Development Program Office and the Oak Ridge Operations Office (ORO), and providing DOE with technical assistance.

ORO provides the Laboratory with implementation-level policy, strategy, and programmatic direction in accordance with approved plans, schedules, and costs. Its other responsibilities include (1) assisting in the development of the national management plan and the national program plan, (2) providing program guidance to other participating field units, and (3) providing technical staff input to the program and full services support in all

business management areas. Furthermore, it directs ORNL's performance in executing technical and financial aspects of the program and makes recommendations to DOE Headquarters on corrective changes in management, program scope, and funding.

Also included in ORNL's responsibilities is the management of subcontracts. Currently, the University of Washington is analyzing fish passage and turbine mortality; Science Applications, Inc., is determining the research necessary at four DOE demonstration sites; and the University of Tennessee is assisting with analysis of water level fluctuation issues. Future subcontracts for research at DOE demonstration sites should range from 25 to 40% of the total project costs.

By participating in DOE-sponsored regional workshops, ORNL effects the direct transfer of program information to small hydroelectric project developers and state and local agencies. Information gained from research at DOE demonstration sites will be directly available to demonstration project developers and, through the publication of research results, indirectly available to other developers. Similarly, literature reviews and analyses will be made available as published reports.

This program is supported through the Field Task Proposal BH 00002.

Summary of resources – Environmental Analysis and Research for Small Hydroelectric Technology[a]

	'79	'80	'81	'82	'83	'84	'85
Operating cost	0.3	0.5	0.7	1.0	1.2	1.2	1.2
Subcontracting and procurement	0.1	0.2	0.2	0.4	0.4	0.4	0.4
Direct FTE	4	4	6	7	7	7	7

[a]Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. Personnel numbers are in full-time equivalent (FTE) person-years.

Other DOE Program Offices

Administrator, Energy Information Administration

To help meet the needs of energy policymakers for reliable and credible information, ORNL provides research and management support for the Energy Information Administration (EIA). These tasks are in areas in which the Laboratory has both interest and experience, including energy consumption data, energy demand modeling, data and model validation, and other aspects of scientific measurement, information processing, and energy modeling and analysis. They are accomplished without the allocation of substantial numbers of internal personnel.

For the Office of Energy Information Validation (OEIV), ORNL conducts research on information and model validation methodologies, manages several subcontracted validation studies of information systems used by energy policymakers, and evaluates the validity of selected energy models. This work involves not only economists, statisticians, and information system specialists but also other ORNL professional staff who have experience with data and model validation; for example, staff of the Engineering Physics Division with recognized expertise in evaluating models of nuclear reactor behavior are contributing to the evaluation of energy-economic models. The data system validation studies should be completed by 1985.

For the Office of Applied Analysis (OAA), we have initiated a research program in which we are developing a system of integrated demand models that will link a variety of detailed sectoral models. Expected to be a long-term Laboratory effort, the program also includes continued attention to demand models for the residential, commercial, industrial, and transportation sectors. This development program is coordinated with that of the evolving Mid-Range Energy Forecasting System (MEFS). We are also exploring the possibility of using our regional energy analysis capabilities to help EIA meet the needs for information about the regional implications of national energy issues.

For the Office of Energy Data, ORNL will, on a continuing basis, update the transportation-sector portion of the End Use Energy Consumption Data Base, maintain data systems and develop estimation methods as needed for the data base, and assist EIA in identifying trends and policy implications in the data. This program will require only a small commitment of Laboratory resources.

Increasing emphasis is being given to relating these programs to other research activities at the Laboratory. The proficiency gained through the validation of energy models, for example, will be applicable to evaluating the models used in other fields. In addition, our data validation and data systems experience should suggest fundamental requirements for the generation of new data.

Lead Mission for the Administrator, Energy Information Administration

Fossil Energy Technology and Consumption Data Systems and Model Validation (current role). The objective of this program, supported by the EIA OEIV, is to determine the validity of energy-economic data and models. The program includes methodology development and application and provides quantitative uncertainty estimates for the data sets and models of interest in policy analysis. The mission work, which continues an ORNL program begun in 1978 under *Comprehensive Data Validation of Selected Energy Data Systems* (see Activity No. FK 03 01 00 0 for WPAS/FTP No. 0001), is an integral part of OEIV's research programs in information and energy data analysis. To date in the program, (1) three reviews of data requirements for about 50 subject areas of DOE interest have been completed in an effort to determine whether extensive validation studies are actually required; (2) validation studies of 6 of about 180 candidate data collection systems and data bases have been reported; (3) the model validation task has been defined and has been demonstrated using the first model of interest (LEAP); and (4) techniques for a computer-based working tool for data control and monitoring have been developed to provide information management support for a National Energy Information System. These tasks indicate the areas of research and demonstration being pursued in the development of model and data validation standards.

Assignment of lead laboratory responsibility to ORNL was jointly proposed by the Acting Assistant Secretary for Energy Technology and the Administrator of EIA. As lead laboratory, ORNL draws from its interdisciplinary capabilities to perform program tasks. A major responsibility is to link model validation results to data acquisition programs and to link data base uncertainties to model validation. Conceptual approaches and analytical methodologies developed within the Laboratory are made available to subcontractors and DOE.

The Oak Ridge Operations Office (ORO) is responsible for providing ORNL with implementation-level policy, strategy, and programmatic direction in accordance with approved plans, schedules, and costs. It lends additional support to the project by providing (1) assistance in the development of the national management plan and the national program plan, (2) program guidance to other participating field units, (3) technical staff input to the program, and (4) full services support in all business management areas. ORO also directs ORNL's performance in executing technical and financial aspects of the program and makes recommendations to DOE Headquarters on corrective changes in management, program scope, and funding.

ORNL's lead mission responsibilities include the management of subcontracts, which are issued for work that is not appropriate to a research laboratory or for research tasks that exceed the Laboratory's personnel resources. Subcontractor evaluations and detailed source selection justifications will be prepared and coordinated with ORO and OEIV when subcontracts are submitted for approval.

Coordination of these activities with related programs is an important Laboratory task. For example, there are related programs at the MIT Model Assessment Laboratory, the Energy Modeling Forum, and the Utility Modeling Forum. Additional DOE programs are carried out at the National Center for Analysis of Energy Systems at Brookhaven National Laboratory (BNL); these include programs for modeling energy supply and demand, sponsored by the EIA OAA; for development of a National Energy Information System and for energy data collection and interpretation, by the EIA Office of Energy Data; and for sector-specific energy use analysis, by the DOE Office of Conservation and Solar Applications. Research at Lawrence Livermore Laboratory (LLL) is developing economic models and algorithms. Work in this program is also supported by the DOE Office of Technical Information/Intergovernmental and Institutional Relations, which has developed counterpart bibliographic data management tools for numerical data.

Relative to our effort to coordinate mission activities with other programs, we process and disseminate verified and validated energy-economic data and codes. DOE has used the evaluation of current energy information systems generated through this program to redesign its data collection systems; these evaluations also assist data users in applying the data from the systems and in executing voluntary and mandatory federal data collections procedures. The methods for validating energy information are employed by OEIV to refine the validation project, to aid others in the field, and to enable DOE data collectors to assess guidelines for improving data quality. Information-processing and data-handling techniques are used to improve system efficiency and will be applied to improving data.

Summary of resources – Fossil Energy Technology and Consumption Data Systems and Model Validation[a]

	'79	'80	'81	'82	'83	'84	'85
Operating cost	3.1	4.6	5.4	5.5	5.5	5.5	5.5
Capital equipment	*	0.1	0.1	0.1	0.1	0.1	0.1
Subcontracting and procurement	2.0	2.6	2.8	2.8	2.8	2.8	2.8
Direct FTE	6	11	13	15	15	15	15

[a]Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. An asterisk indicates funding of less than $50,000. Personnel numbers are in full-time equivalent (FTE) person-years.

Administrator, Economic Regulatory Administration

For the Economic Regulatory Administration (ERA), ORNL provides technical assistance in analyzing and forecasting energy system performance, prepares impact assessments of proposed regulations, and conducts related research. In our systems performance analyses, we are performing reliability assessments, identifying issues and options in linking cogeneration and/or district heating systems with utility systems, and evaluating related policy options, such as load management. Relative to this last effort, we have proposed a program for monitoring the response to time-of-day electricity pricing in central Vermont. The impact assessments being prepared for ERA cover a wide range of subjects. Examples are the environmental effects of the Fuel Use Act; the economic, environmental, and administrative impacts of emergency energy conservation policy options; and the regional implications of possible regulatory actions. In addition, ORNL undertakes limited projects on a case-by-case basis, subject to the availability of research staff. In many instances, our research and service provides ERA with the technical base necessary to prepare the reports mandated by the National Energy Act and other federal energy legislation.

Assistant Secretary for Policy and Evaluation

ORNL contributes to Policy and Evaluation by conducting research and providing technical assistance in areas in which it has special expertise and analytical capabilities, particularly in technology and impact assessments. Currently, our work includes assessments of the effects of conservation policy alternatives on energy consumption, the regional impacts of national policies, and the environmental and social impacts of possible national energy policy initiatives. As appropriate, the Laboratory also provides other technical information and evaluations to support policy formulation. During this planning period, we expect to continue our limited role on a spot basis.

Office of the Undersecretary, Department of Energy

In developing plans for the Strategic Petroleum Reserve, ORNL is assisting the Source Evaluation Board, at DOE's request, in evaluating environmental impact control plans for the proposed installations. As the project matures, this support should expand to broader areas of environmental assessment.

Isotope Production and Distribution

The Laboratory administers DOE programs for the production and distribution of enriched stable isotopes, radioisotopes, and heavy elements. These programs must be responsive to DOE needs as well as to market requirements. Consequently, long-term projections of the demand for or sales of their products are difficult to make with any degree of certainty. Thus, we rely heavily on past trends to predict the programs' future activity levels.

These programs offer the above-mentioned materials for sale or loan and provide some associated services. They supply over 300 products and services—none of which are commercially available from the U.S. private sector—to about 2500 domestic and foreign customers in the fields of education, medicine, research, and commerce. At ORNL, distribution of these products and services is made by the Isotope Sales Group in the Operations Division. The Chemical Technology, Solid State, and Health and Safety Research divisions are also routinely involved, and circumstances may require the participation of other divisions.

Responsibility for this area of work is shared by several organizations. The DOE Division of Nuclear Sciences (under the Director of the Office of Energy Research) is responsible for work relating to enriched stable isotopes and most heavy elements; the Office of Management Support (under the Assistant Secretary for the Environment) is responsible for the part of the program concerned with radioisotopes and their by-

products. The Office of Nuclear Materials Production under the Assistant Secretary for Defense Programs is responsible for the production and distribution activities for certain heavy elements.

Stable Isotopes

The Laboratory's stable isotopes separation activity, performed as part of the ORNL Stable Isotope Production and Distribution Program, uses several of the calutrons, or electromagnetic separators, that were originally constructed for wartime production of weapons-grade uranium; they are now used to separate stable isotopes from most of the periodic table. These isotopically enriched materials are used to determine basic nuclear properties as well as neutron data for the design and operation of fission and fusion reactors. In addition, they serve as mass spikes for analytical determinations and as target materials for the production of commercial radiation sources and radiopharmaceuticals used in nuclear medicine.

About 24 staff members are involved in this production activity. A portion of the program's operating costs is recovered through sales to foreign and domestic customers, the U.S.S.R. being the only other major supplier of isotopically enriched materials. The remainder is recovered from DOE's Office of Basic Energy Sciences (OBES). The potential for substantial cost recovery is great, but the current pricing and cost-recovery policies do not allow us to make the operation financially self-supporting through sales. During the 1979 review of the Laboratory's long-range plans, the Assistant Secretary for Energy Technology requested that OBES revise the accounting system and policies so that self-financing would be possible.

The program also receives support from OBES for its efforts related to the Research Materials Collection (RMC), which provides isotopes for loan to those researchers (primarily in the United States) who demonstrate a need for such material and will use it only in nondestructive experiments. These activities involve maintaining the RMC, providing materials for it, and upgrading its inventory.

Radioisotopes

The ORNL Radioisotope Production and Distribution Program provides a total of 71 products as well as technical services such as cyclotron irradiations and radiation source fabrication. These products and services, which are used in medical, industrial, and research applications, are not commercially available from U.S. private industry. Through the ORNL program, they are offered for sale and are purchased by about 1500 domestic and foreign organizations.

The products provided by this program are produced at ORNL and at ten other DOE sites and, like the stable isotopes, are distributed by the Isotope Sales Group. The major products are tritium [produced at Savannah River Laboratory (SRL)], ^{192}Ir (produced at ORNL), ^{241}Am [produced at the Rocky Flats plant, SRL, and Los Alamos Scientific Laboratory (LASL)], ^{85}Kr (produced at ORNL using feed from the Idaho Chemical Processing Plant), and ^{127}Xe [produced at Brookhaven National Laboratory (BNL)].

The prices for radioisotope products and services are set to recover production costs; an added factor of about 30% covers depreciation and DOE and sales-group costs. We expect costs to increase in FY 1980 and FY 1981 because of the possible assumption of ^{99}Mo production capability as a backup for the only domestic commercial producer of this radioisotope and because of increased deliveries of ^{241}Am from other DOE sites. From FY 1982 through FY 1985, costs should be relatively stable. Personnel levels associated with radioisotope production, however, should increase slightly, to 43 in FY 1980 and to 47 in FY 1981. If we are directed to provide backup ^{99}Mo production, we will need to add seven staff members.

We foresee major problems related to funding of capital equipment items, which by regulations cannot be charged to production operating expense, and to the effect of the DOE-imposed personnel planning levels on organizing for any increased production responsibilities specified by DOE. These responsibilities have increased in recent years and may continue to do so. Since November 1977, for example, we have assumed the interim production of several radioisotopes formerly produced by the General Electric Test Reactor (GETR) before its shutdown at the direction of the Nuclear Regulatory Commission (NRC). These radioisotopes—^{192}Ir, ^{63}Ni, ^{75}Se, ^{119m}Sn, and others—are vital to the industrial and medical communities. If the GETR remains inoperative, which now seems likely, we will be required to continue production of these radioisotopes and to assume the production of others that would otherwise be unavailable from domestic sources. In addition, the assumption of ^{99}Mo production capability, mentioned previously as a possibility, may increase our production responsibility.

Nuclear Regulatory Commission

Technical Thrust

Through its various programs at ORNL, the NRC receives research and technical support in areas in which the Laboratory has demonstrated technical expertise. The research conducted on NRC's behalf emphasizes hydraulics, heat transfer, solid mechanics, fuel and cladding behavior, instrumentation, fission product technology, aquatic and terrestrial ecology, and health sciences. Technical support, which is provided as required, is related to environmental impact statements, standards and codes, instrumentation, materials, social science, and information management.

Reactor Safety Research. The Laboratory's multifaceted reactor safety research program concentrates its efforts in five areas—systems engineering, fuel behavior, metallurgy and materials, research applications, and safety for specific types of reactors. The focus of research in the first area is the Blowdown Heat Transfer Program, which relies heavily on the Thermal Hydraulic Test Facility for separate effects testing of transient thermal hydraulics analysis in accidents such as depressurization or loss of coolant. Fuel-behavior experimental research also involves testing under simulated accident conditions. In this work, we are investigating (1) cladding failure of pressurized fuel rods of the pressurized-water-reactor type in a prototype bundle subjected to loss-of-coolant-accident (LOCA) conditions; (2) cladding creepdown during in-pile fuel exposure; (3) nuclear decay heat released after a nuclear "scram"; and (4) fission product release and transport during core meltdown, LOCAs, or shipping accidents.

Our metallurgy and materials work includes the Heavy Section Steel Technology Program, which studies, under operating and accident conditions, the basic properties ensuring reactor-vessel integrity. Additional research in this area is performed through the Pressure Vessel Irradiation Program, which investigates the properties of materials irradiated in a prototype neutron spectrum, and through an effort examining design criteria for piping and nozzles.

As part of our research applications programs, we develop, fabricate, and test in-vessel flow instrumentation for the international 3-D Reflood Program; perform diagnostics instrumentation research and human-factors studies of operator response and action; develop advanced two-phase-flow instrumentation; and carry out safety information center activities. The 3-D instrumentation work, in particular, has a demanding schedule tied to international commitments and should undergo a phase-down and rapid completion between 1980 and 1981.

Programs that reflect concern for safety related to specific reactor types include the Aerosol Release and Transport Program and the High-Temperature Gas-Cooled Reactor (HTGR) Safety Analysis Program. The former program investigates the release and transport of radionuclides from liquid-metal fast breeder reactor fuels under a range of accident conditions. Using a capacitor-discharge fuel-vaporization system in air, water, or sodium in a scale containment, this program also provides data for testing complex accident analysis codes. In the HTGR Safety Analysis Program, we are performing dynamic modeling and code testing of HTGR behavior in transients, which includes analysis of transients occurring during operation of the Fort St. Vrain reactor.

Safeguards, Fuel Cycle, and Environmental Research (SAFER). An example of ORNL's work in these areas is the aquatic ecology research in which we are examining the impact of reactor cooling systems on aquatic life; this research is primarily concerned with impingement and entrainment. Other activities include development efforts aimed at standardizing the analysis of fuel shipping containers and providing dosimetry and biotransport models to implement "as-low-as-reasonably-achievable" (ALARA) guides for the release of radioactive materials.

Probabilistics Analysis and Risk Assessment. The Laboratory's support of probabilistics and risk assessment will continue to increase moderately. Currently, this activity includes analysis and verification of data, examination of acceptable risk criteria, and development of basic mathematical methods and of information from which to examine accident-sequence precursors. We are reviewing and planning projects in the man-machine interface area as well as performing a limited number of risk studies. Furthermore, initial work in concepts for improving light-water reactor safety previously originated in the probabilistics and risk area and may continue to do so.

Standards Development. At the Laboratory, technical support related to standards is provided in several areas for the Office of Standards Development (OSD). These include reactor materials development, codes and standards, nondestructive examination, reactor surveillance and diagnostics,

radiation exposure from products, and internal dosimetry.

Nuclear Materials Safety and Safeguards. Our efforts in this area provide technical support to the Office of Nuclear Materials Safety and Safeguards (ONMSS). Among these efforts are evaluation of terminated licenses, assistance in shipping cask analysis, safety review and environmental assessment of fuel cycle facilities, investigation of radon releases from uranium mines and mills, and safeguards analysis for by-product materials and small quantities of special nuclear materials.

Nuclear Reactor Regulation. The focus of this work, which is conducted for the Office of Nuclear Reactor Regulation (ONRR), has in the past been the preparation of environmental impact statements. ORNL has provided teams of engineers, social scientists, and environmental scientists to prepare such statements for each assigned plant and to follow through with hearing testimony and review until final statement acceptance. We expect, however, that these activities will decline in the future. The major part of our work for ONRR is now technical support work that includes direct assistance in reactor regulation involving electrical and control systems, surveillance and diagnostic instrumentation, power systems, nondestructive examination, and welding.

Administration. We furnish technical support for this facet of NRC operation through the Radiation Shielding Information Center, the Technical Data Management Center, and the Radiation Exposure Information and Reporting System.

Major Changes

The impact of the Three Mile Island (TMI) accident on future NRC programs will be substantial. We envision a programmatic shift from research focusing on the LOCA and previous regulatory needs to a broader, more holistic analysis of reactor safety. As a result, additional data will be needed to enable understanding of accident retention associated with core cooling and containment and to ensure such retention. In addition, methods for analyzing and coping with transients that may lead to accident conditions must receive new emphasis. The outcome of this broader research will be the revision of reactor systems in order to improve their stability, accident protection, decay heat removal, containment, and core-melt retention. After careful examination, the man-machine interaction will also be substantially revised through the addition of better training, improved instrumentation and controls, and computer assistance. Finally, to ensure preparedness for an accident, all aspects of accident response, communications, command, public protection, and cleanup will be studied and improved.

Major Issues

A substantial number of our current programs are either being completed or should be completed during this planning period. Important and much-needed new work has been identified, but details of specific programs have not yet been finalized.

Although the technical base exists to accommodate the TMI follow-up, efforts toward this goal are fragmented among NRC, DOE, the Electric Power Research Institute (EPRI), and private industry, which may place the burden of planning on the relatively few individuals having experience with reactor systems, instrumentation, and materials under accident conditions. The completion of existing programs will result in a reduction from $18 million in 1980 to $12 million in 1981; this reduction is largely associated with the completion of both the Blowdown Heat Transfer Program work and much of the support for the fast-paced 3-D Refill Program. This planned funding reduction and the diverse capabilities of ORNL provide us with an apparent capability for accommodating new efforts resulting from the TMI accident.

Non-DOE Sponsors (excluding the Nuclear Regulatory Commission)

A significant amount of the Laboratory's effort—about 250 full-time equivalent person-years—is directed toward sponsors other than DOE and the Nuclear Regulatory Commission (NRC). Most of this effort is in the life sciences, and nearly all is supported by federal agencies. Some growth (about 2% per year) is projected for these non-DOE life sciences programs to accommodate possible declines in DOE support of certain areas. We currently project a decline in other non-DOE programs during this planning period. It is, however, particularly difficult to make long-term forecasts in this area because of the diversity of sponsors, shifts among agencies, and the closeness of these programs to DOE missions.

Agencies Funding Life Sciences Work

We derive about 30% of the support for our life sciences programs from outside DOE, primarily from

other federal agencies. In addition to lending strong support to our life sciences effort, a large part of the work funded in this manner is directly complementary to programs conducted for DOE's Assistant Secretary for the Environment.

Because all the program work, regardless of its source of support, is performed in the same laboratories, close interaction occurs among staff, as does a continuing exchange of scientific information. This situation fosters the most efficient use of these important national resources for investigations within the life sciences.

Department of Health, Education, and Welfare

The major efforts supported by the Department of Health, Education, and Welfare (HEW) involve performance of research in carcinogenesis, mutagenesis, toxicology, and teratogenesis; provision of technical information system services; and development of a screening and testing system to give a preliminary indication of the potential mutagenicity or carcinogenicity of compounds. We are also negotiating the renewal of two research projects sponsored by HEW through other organizations. The first involves renewal of a contract with the National Cancer Institute (NCI) from 1979 through 1983 for the study of respiratory carcinogenesis; the second, a renewal of the National Institute of Environmental Health Sciences (NIEHS) program on carcinogenic effects of environmental insults.

Environmental Protection Agency

With the support of the Environmental Protection Agency (EPA), we are exploring the areas of toxic effects of various materials associated with energy production processes, solid waste disposal, and radiation dosimetry. Other efforts are development of a screening and testing system and provision of information systems support to EPA.

Several key accomplishments in EPA-funded work are anticipated during this planning period. These include evaluation of the adequacy of existing test protocols—1980, application of existing multimedia transport models for Toxic Substances Control Act (TOSCA) assessments—1981, and development and implementation of methods for use in assessing compliance with the Clean Air Act—1982. In 1982 and 1983, we expect to develop new ecological test procedures for TOSCA and new multimedia transport models for TOSCA assessments.

National Science Foundation

The major goals of our work for the National Science Foundation (NSF) are to perform ecosystem analysis studies, to study the buildup of atmospheric CO_2, and to develop a small-angle neutron-scattering facility. Key events projected for this planning period include (1) validation of the nutrient spiraling hypothesis on streams—1980, (2) development of an international center of excellence in ecosystem modeling—1981, (3) completion of a disaggregated model of the global carbon cycle —1982, and (4) development of climate-vegetation relationships for the CO_2 model—1985.

Others

Other agencies from which we receive support in the life sciences area are the Forest Service, the National Aeronautics and Space Administration (NASA), the Air Force, and the Fish and Wildlife Service.

The Electric Power Research Institute (EPRI) is another source of support. We are discussing with EPRI the expansion of its support of research related to atmospheric pollutants (SO_2, NO_x, acid rain, and CO_2), toxicity testing systems for toxic substances (chemicals, trace elements such as mercury, and leachates from solid wastes), and aquatic resources. Topics of interest in the last category include cooling systems, entrainment, and waste heat utilization. We hope that this increased level of support will begin during FY 1980 and remain constant at about $1 million per year through this planning period.

We will continue to emphasize joint cooperative programs with the Tennessee Valley Authority (TVA) in various environmental areas, including nonnuclear solid waste management, coal gasification, instrument development, and chlorination effects.

Department of Defense and Defense Agencies

Most of the remaining non-DOE work is also carried out on behalf of other federal agencies. The largest of these is the Department of Defense (DOD); its expenditure for ORNL programs in FY 1979 was almost $2 million. Four programs account for most of these funds. The first, which involved fabrication of Army materials and fuels, has ended. For the three ongoing programs, we will provide radiation shielding information and analysis for the Defense

Nuclear Agency (DNA), conduct civil defense studies for the Defense Civil Preparedness Agency (DCPA), and develop instrumentation for the Navy.

Other Federal Agencies

When work demands the special capabilities of the Laboratory, we also undertake research for non-DOE sponsors in the areas of impact, technology, regional, and policy assessments; conservation and community-scale integrated energy use; resource analysis; and emergency planning. We are currently doing work for EPA, the Department of Commerce (DOC), the Department of the Interior (DOI), the Department of Housing and Urban Development (HUD), and DCPA. Furthermore, a new program provides technical support to DOI's Office of Surface Mining in implementing the Surface Mine Reclamation Act of 1977, and additional research efforts are being discussed with DOI, DOC, NSF, EPA, and EPRI.

Nonfederal Organizations

The Laboratory also receives a small amount of funding from nonfederal organizations, chiefly from EPRI and from the Council for Tobacco Research; both of these organizations rely on ORNL's unique facilities and expertise. For the utilities, we will develop sensitivity analyses applicable in reactor fuel management and in detection of radiation damage to pressure vessels. All programs sponsored by nonfederal organizations require DOE approval before being undertaken.

New Initiatives

In this chapter, we identify important new areas of work that are not discussed in the previous section. The following program descriptions, which are grouped according to sponsoring agency—either a Department of Energy (DOE) office or another government organization—summarize program goals and resource requirements. In general, these new initiatives could not be accomplished within current personnel planning levels and would necessitate an increase in these levels.

New Initiatives for the Assistant Secretary for Energy Technology

Long Pulse Technology Tokamak and Shielded Neutral Beam Test Stand

Recent successes on tokamak experiments at ORNL and at other institutions have reinforced the belief that the necessary tokamak physics base will be developed within the next several years. We must therefore place increasing emphasis on engineering and technology development to raise these areas to an acceptable level. In particular, as a result of The Next Step (TNS) activities, ORNL has identified the need for a Long Pulse Technology Tokamak (LPTT) as an interim device to provide integrated systems experience for implementation of the Engineering Test Facility (ETF). The LPTT, proposed for operation in FY 1984 or FY 1985, would be a superconducting, hydrogen device with a pulse-length capability of tens of seconds. It would allow the logical continuation of the Impurity Study Experiment (ISX) program and would add the systems experience in support of the ETF. Industry would be extensively involved in its design and construction.

Currently, an evaluation of research and development (R&D) needs is under way for the ETF and the International Tokamak Reactor (INTOR) programs. We expect that these assessments will reinforce our conclusions regarding the need for the LPTT, and, on completion, we shall conduct further discussions with DOE's Office of Fusion Energy (OFE). Estimates of resource requirements for the LPTT are shown in the following table.

Summary of resources – Long Pulse Technology Tokamak[a]

	'80	'81	'82	'83	'84	'85
Operating						
BO[b]	0.5	4.5	12.4	10.9	7.4	3.0
BA[c]	2.0	7.1	11.9	9.8	5.9	3.0
Subcontracting	0.2	1.5	3.0	2.5	2.5	1.0
Procurement	0.1	0.3	0.6	0.6	0.4	0.2
Capital equipment	0	4.0	3.0	2.0	2.0	2.0
Direct FTE[d]	0	0	0	0	0	0

[a]Funding for FY 1980 and FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. Personnel numbers are in full-time equivalent (FTE) person-years.

[b]Budget outlay.

[c]Budget authorization.

[d]Extension of ISX-B program will enable us to use existing personnel.

The ETF will require reliable neutral deuterium beams of 150 to 200 keV and 50 to 100 A that have pulse lengths of 20 to 100 sec. These requirements exceed the capabilities of current neutral beam test stands. The proposed Shielded Neutral Beam Test Stand would allow testing of ETF beam lines. Construction of the facility, at a cost of about $10 million to $20 million, would require four to five years; input to the ETF design is required by the mid-1980s. Thus, even though some people believe that neutral beams are not the optimum heating approach for commercial power reactors, the development of greater beam-testing capabilities, including the proposed test stand, must be initiated to meet ETF needs. ORNL will be developing more detailed cost and schedule information and has initiated discussions with OFE concerning the need for this facility.

Advanced Technologies Applicable to Light-Water Reactors

Inquiries from the utility industry indicate that technologies being developed for the breeder reactor program could also support DOE initiatives calling for utility-managed programs in the following three major areas of light-water reactor (LWR) improvements: (1) improved uranium use, (2) reduced levels of occupational radiation exposure, and (3) near-term solutions to technological problems that have potential for seriously compromising overall LWR plant on-line time.

Technologies facilitating improved uranium use include gel-sphere-pac fuel. Developed by ORNL primarily for refabrication in recycle fuel systems [see discussion in the preceding chapter under "Consolidated Fuel Reprocessing (AG 20 40)"], this fuel can potentially reduce or eliminate problems of pellet-cladding interactions in the once-through fuel cycle. Such improvements could lead to substantial gains in fuel use (an 8% savings in U_3O_8 is the current program goal) through higher burnup factors. An irradiation test program involving burnups of up to 50,000 Mwd/tonne is required to evaluate fully the potential afforded by gel-sphere-pac fuels. The total effort, including the generation of statistically significant data in real LWR environments, would require eight to ten years; however, no additional facilities at ORNL would be needed for this demonstration effort.

With respect to reductions in occupational radiation exposure, ORNL has very strong staff and facility capabilities for conducting high-temperature aqueous chemistry and corrosion investigations. These capabilities could be applied to produce effective component decontamination methods and primary-coolant-loop radiation control chemistry techniques. Existing facilities at ORNL could be made available for large-scale demonstrations of this latter technology. The demonstrations would use contaminated reactor artifacts and, if required, could include testing under irradiation conditions.

Improved systems currently under development at ORNL for the detection and interpretation of flaws in materials could be applied in both the manufacture of components for nuclear steam supply systems and the nondestructive examination of such components during in-service inspection. ORNL has strong capabilities in automated welding equipment and techniques, particularly for pipe and tube welding, suitable for remote maintenance or repair [e.g., replacement of cracked boiling-water reactor (BWR) piping] on relatively short notice.

In the area of in-core instrumentation, we recently proposed work to DOE for qualification of gamma thermometers for in-core local power measurement in LWRs. Several domestic and foreign utilities have shown definite interest in these devices because of their inherently higher accuracy and reliability relative to the self-powered neutron detectors now in use.

At the April 26, 1979, onsite review of ORNL, the following guidance was given by Dr. Deutch, who, at that time, was Acting Assistant Secretary for Energy Technology: "In contrast to the guidance in the feedback on last year's *Institutional Plan*, DOE now plans to fund LWR work so that efforts need not be limited to programs sponsored by EPRI [the Electric Power Research Institute] or the utilities."[1]

Light-Water Reactor Safety

In FY 1979, the Laboratory's Instrumentation and Controls (I&C) Division began work on a long-term program in improved LWR control systems. This DOE-funded work, which is managed by the Sandia Laboratories and which should extend through the late 1980s, calls for significant ORNL involvement. The Laboratory will assist Sandia in designing the overall program plan as well as in performing selected technical tasks, such as developing operator aids for upset analysis.

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[1]Memorandum from J. A. Lenhard, DOE—Oak Ridge Operations Office, to D. M. Kerr, DOE—Energy Technology, Subject: Oak Ridge Minutes of Onsite Review, dated May 4, 1979.

Sandia Laboratories informed us in May 1979 of a major revision of the goals for the long-range LWR safety program. The revised goals are aimed at improving man-machine interaction through technology developments that will (1) provide on-line diagnostic information, (2) facilitate on-line analysis of plant safety margins and the prevailing status of plant safety systems, (3) increase operator control over randomly occurring plant disturbances, and (4) increase on-line capability for detecting errors occurring during maintenance and fuel-handling operations. In addition, ORNL has identified three other major areas meriting priority consideration: (1) improved understanding of core and primary-system behavior during unusual transients and/or loss-of-coolant-accident (LOCA) conditions less severe than a double-ended, large-line break; (2) the capabilities of plant radioactive waste and fluid-handling systems; and (3) emergency response planning.

Currently, the Laboratory is identifying tasks in which our staff and facility capabilities could be applied to these revised goals. We anticipate being able to contribute significantly to improving generic LWR safety through these I&C efforts as well as through work in other relevant technology areas.

Instrumentation for Fission Energy Systems

The Laboratory is proposing to lead a unified program to develop I&C technology that will improve the performance and safety of fission energy and related systems. Our function would be to coordinate the many I&C activities related to energy generation and conversion systems through a management center that would consolidate work in the three major I&C areas: Detection and Measurement, Signal Processing and Data Management, and Improved Control, both automatic and operator assisted. Such coordination would eliminate duplication in development efforts on similar devices and systems.

Concepts for Proliferation-resistant Fuel Cycles

The Proliferation Resistant Concepts Program will develop engineering systems in reprocessing that could significantly increase the diversion resistance in two ways: by further reducing human access to process equipment and operations involving fissile materials and by improving the capability of remote monitoring operations so that conclusive information regarding diversion threats or covert plant modifications can be obtained.

The first objective will be accomplished by developing and demonstrating advances in the state of the art of force-reflecting electromechanical manipulators. By mounting the manipulators on a remote maintenance cart traversing the length of a reprocessing cell, the need for human access to the process area can be eliminated. Also, an automated sampler system will be developed that is capable of withdrawing a process stream sample from a sample line inside the cell near the vessel and delivering it to the analytical laboratory. The elimination of sample lines outside the main cell will prevent direct withdrawal of weapons-significant quantities of material through sample lines.

The second objective will be met by developing and demonstrating techniques for extending process control systems to incorporate the surveillance of information regarding attempts to divert materials and by passive measures to deny access to or use of materials. The key elements of the concept are a command, control, and communications network to detect diversion threats and a use-denial system for aborting diversion attempts.

The surveillance system will provide for monitoring (1) the process instrumentation normally used for process control and fissile material accountability, (2) the safeguards instrumentation dedicated to the physical protection of the facilities, and (3) special instrumentation that has been added to indicate the state of the plant. A computer will continuously analyze the data, and a data discrimination system will be devised that can distinguish abnormal situations.

Flue Gas Desulfurization Program

Responsibility for the development and demonstration of environmental control technology for SO_2, NO_x, and particulate emissions from power plants fired by pulverized coal has been transferred from the Environmental Protection Agency (EPA) to DOE. Consequently, DOE is implementing a large program (estimated at $25 million in FY 1979) in this area. The Laboratory and the Oak Ridge Operations Office (ORO) of DOE have proposed a joint program on the development of flue gas desulfurization. The program would benefit in both its management and technical capabilities from (1) the management expertise gained by ORNL and ORO through experience with programs of similar size; (2) the chemical engineering and applied chemistry expertise

available at ORNL; and (3) the strong ties of both organizations with the Tennessee Valley Authority (TVA) and EPRI, who have large programs in this area. In addition to conducting substantial experimental R&D, the Laboratory would provide technical management in concert with DOE-ORO personnel.

Supercharged Fluidized-Bed Combustor Program

For the past four years, the Laboratory has proposed the development of a supercharged fluidized-bed combustor as an intermediate step between atmospheric fluidized-bed combustion (AFBC) and pressurized fluidized-bed combustion systems. A design would be chosen for the supercharged system, which would operate with a combustor pressure of 3 to 4 atm, that would not necessitate hot-gas cleanup of the combustor flue gas; hot-gas cleanup is required by pressurized fluidized-bed combustors to avoid severe turbine materials problems. Expected advantages of the supercharged system over AFBC systems include reduced capital cost through reduced bed area and feed system complexity, increased combustion efficiency, reduced environmental emissions, and improved turndown ratio.

The extensive background of ORNL in evaluating advanced power systems for utility and industrial applications and its growing involvement in AFBC development would provide strong support to a unified program for developing the supercharged fluidized-bed combustion system. The Laboratory, in addition to performing a substantial part of the supporting R&D, would provide technical management of the program together with DOE-ORO personnel and would identify the roles and assignments of other contractors in the program.

Coal Cleaning Plant Automation Program

The Pittsburgh Mining Operations Center has given the Laboratory the lead responsibility in a program for automating physical coal cleaning plants. The principal thrust of this multiyear program is to apply I&C methods and systems to coal cleaning plant operations to improve coal product quantity and quality. During the program's first year, the availability of and need for I&C systems will be assessed. When necessary, promising instrumentation, including devices for on-line measurement of sulfur and mineral matter, will be developed and demonstrated. Later phases of the program will involve the evaluation of control systems under field conditions and the design of fully automated coal cleaning systems. Program tasks will also include analyses to determine the cost effectiveness of potential control systems.

ORNL's extensive background in the application of process control instrumentation to a variety of systems will lend strong support to the program. Cooperative programs are expected to develop with TVA, EPRI, and several industrial companies active in coal mining and cleaning. Along with providing technical management for the program, the Laboratory will carry out substantial R&D, using, where possible, strengths available at industrial and academic sites.

Low-Grade Heat Recovery

The Laboratory is responsible for managing the low-grade heat recovery portion of the National Waste Heat Utilization Program. Although this new initiative is a direct outcome of the preliminary activities associated with issuing a Program Research and Development Announcement (PRDA) for low-temperature heat utilization during FY 1978, its role is much broader than that described in the PRDA. ORNL will be responsible for managing contracts and in-house research for conversion technology, thermodynamics, heat engine development, and heat pump applications for heat recovery. With respect to this initiative, we worked with DOE during FY 1979 to define the direction of future contracting activities, to determine the amount and types of in-house research, and to prepare a management plan.

New Initiatives for the Director of Energy Research

Coal Chemistry

Important chemical changes occur in carbonaceous matter when it is thermolyzed for a few minutes at about 400°C. These chemical changes partly involve a breaking of bonds in the organic polymer network that is a fundamental feature of coal molecular structure. The breaking of the bonds in this network lowers the molecular weight of the carbonaceous matter, which is an important factor in the production of coal-derived liquids in several current processing schemes, such as the Solvent Refined Coal (SRC) and the Exxon Donor Solvent

(EDS) processes. Understanding the nature of these thermolysis reactions and the functionalities they create or destroy requires new knowledge of coal structure and bonding as well as investigation of the mechanisms of the more important reactions.

In one approach the Laboratory is taking in this research, ^{14}C-labeled reagents, such as the hydrogen donor tetralin, are being used to study some of these reactions. We recently discovered a rearrangement new to organic chemistry that leads to the dehydration of certain types of ethers that undoubtedly occur in coal. This dehydration of ethers provides a new mechanism for the appearance of water as one of the products of coal thermolysis. This work will continue with the purposes of establishing further structure reactivity relationships for bond thermolysis and of learning, through the use of deuterium labeling, what happens to hydrogen in aliphatic and aromatic positions.

In our studies of coal thermolysis, we will also use our recently completed high-resolution solid-state nuclear magnetic resonance (NMR) instrument, which executes experiments employing dipolar decoupling, magic angle spinning, and cross-polarization. The solid coal and the liquids derived from it will be studied by NMR to determine the chemical changes that take place during conversion. For example, the supposition that phenolic hydroxyl groups are increased by rapid heat treatment will be tested.

In addition to using thermolysis to degrade coal, reactions operative even at 0°C have been studied. It is important to examine such potentially simpler methods of breaking down the coal polymer network to learn the nature of coal molecular structure. Our approach to low-temperature degradation employs a specially formulated organic solution of sodium and potassium (NaK) that contains highly reactive solvated electrons. We have shown that aryl-alkyl carbon-carbon bonds can be cleaved using the NaK solution—a previously unknown reaction. These studies with coallike molecules (model compounds) will give enough information by FY 1981 to allow us to study the reaction details in coal itself.

Our first specific subject will be Illinois No. 6 vitrain. After the fractions obtained are separated by various techniques, including chromatography, according to functional group, molecular size distributions will be made, partly by small-angle neutron scattering (SANS). The substances produced by thermolysis will be compared with those produced by various chemical degradation procedures, such as reductive alkylation, Friedel-Crafts acylation, and reduction with the organic NaK solution. This study of Illinois No. 6 vitrain should provide much useful information on its molecular structure and consequently should contribute to the further development of liquefaction processes, for fragmentary information now available indicates that different coals differ at the molecular level in ways possibly important to liquefaction procedures. Therefore, these studies on Illinois No. 6 vitrain will be extended by FY 1983 to other important bituminous and subbituminous coals.

We intend, then, to increase our efforts in coal chemistry research during this planning period. The knowledge being obtained here and elsewhere is already changing the thinking of the coal chemistry and chemical engineering communities about the nature of coal and its reactions. Ultimately, these findings should provide a knowledge of coal chemistry at least comparable to our current knowledge of the nuclear and petroleum energy technologies.

High Temperature Materials Laboratory

A major problem with nearly all energy technologies is the availability of materials having appropriate properties at very high temperatures. The new High Temperature Materials Laboratory (HTML), which should be completed by FY 1985, will be a unique laboratory for basic and applied research on materials at elevated temperatures; it will facilitate precise measurement of physical, chemical, and metallurgical properties and very long term experiments. Furthermore, the HTML will allow initiation of new programs and expansion of current ones in several general research groupings: mechanical behavior, environmental interaction, property measurements, structural characterization, materials synthesis and preparation, and high-temperature chemistry. Preparations for industry involvement, estimated at five to six full-time equivalents (FTEs) per year by 1985, have already begun.

Holifield Heavy Ion Research Facility, Phase II

To enhance heavy ion research capabilities, a Phase II addition to the Holifield Heavy Ion Research Facility (HHIRF) is being planned that will greatly expand the available ion energy capabilities. The facility, to be designed as a national facility with

the capacity to support a large users organization, will provide coverage of the energy region from 20 to 400 MeV/A. Planning and design are expected to continue to FY 1981; a proposal for funding will be presented later in this planning period.

Low-Grade Ores

Because high-grade domestic sources of several important raw materials such as aluminum and uranium are already in short supply and because other necessary commodities are expected to become equally scarce, even on a worldwide basis, R&D must begin on methods to obtain these materials from less desirable but more plentiful resources such as low-grade ores or waste substances. Specifically, the Laboratory proposes to develop techniques for recovering fuel materials such as uranium and thorium. In general, we will work to determine the most energy-conserving concepts for extracting metals and other important commodities from potential low-grade sources.

As part of this effort, TVA, among others, has developed a process that produces phosphoric acid at 40% concentration that is more energy efficient than the processes currently being used to produce dilute acid. The uranium, however, cannot be extracted from this concentrated acid with the extractants developed for dilute phosphoric acid. Thus, in FY 1979, we began a cooperative project with TVA to find extractants and to develop processes for extracting uranium from the concentrated acid.

National Synchrotron Light Source

Collaborative efforts with the university community are currently under way to instrument a beam line on the x-ray storage ring at the National Synchrotron Light Source (NSLS) at Brookhaven National Laboratory. ORNL and Oak Ridge Associated Universities (ORAU) have jointly proposed a similar collaborative effort to instrument a beam line at the vacuum ultraviolet (VUV) storage ring at the NSLS.

High-Level Waste Isolation

The disposal of high-level radioactive wastes that result from nuclear reactor operation presents a critical problem to the future of power generation based on fission devices. High-level nuclear wastes must be stored, isolated, and contained for very long periods. In FY 1980, research investigating potential methods for nuclear waste isolation will begin. Laboratory-prepared analogues of minerals known to be extremely stable chemically and highly resistant to geological processes will be grown and doped with radioactive materials such as the actinides. A variety of chemical and physical techniques will be applied to these materials in FY 1981 and FY 1982 to answer such questions as (1) What is the chemical form of the radioactive material? (2) How is it incorporated into the solid? (3) To what extent is it removed from the solid by leaching in different solutions under varying temperatures and pressures? By FY 1983, tests to determine the geological properties of these solids and how to incorporate them into granites should begin. The first class of synthetic minerals investigated will be the lanthanide orthophosphates, which are analogous to the monazite minerals; these minerals are especially interesting because in nature they contain uranium and thorium as well as the rare-earth elements.

Social Science Research

Many of the goals and instruments of energy policy are social, economic, and institutional. Applied energy research by social scientists is hampered, however, by the inadequacy of existing social science theories, methodologies, and data. In light of this fact, we have discussed a research program with the Advanced Technology Projects Division of DOE's Office of Basic Energy Sciences (OBES) that would fill such gaps through fundamental research in priority areas, as identified by DOE applied research program managers. The program would be conducted in collaboration with first-rate scholars in universities and other institutions. A formal proposal is being prepared for consideration in FY 1980.

Biological Energy Research

We expect biological energy research to become an increasingly important area of basic support. Areas of particular concern at ORNL include (1) the application of microbial and bioengineering techniques to the production of fuels and chemical intermediates, (2) improvement of currently available industrial strains that produce or degrade energy-related compounds, (3) novel processes for industrial application that conserve energy, and (4) alleviation of some pollution problems currently related to energy generation or to the direct use of novel energy systems. Major interrelated projects

include those in the areas of woody biomass production, coal runoff and trace elements production, coal liquefaction, and synfuels.

In FY 1980, ORNL plans to initiate a study of the mechanisms by which microorganisms attach to solid surfaces; this study will provide a base of knowledge for the applied programs proposed for FY 1982 and beyond in which potential applications of microorganisms in energy production (e.g., methane production) will be studied. Two interrelated projects concerning the production of fuels and fuel-replacing materials from biomass resources will be started in FY 1980; these are expected to continue through this planning period and beyond. The goals of these projects are (1) to improve the rate of lignin hydrolysis by chemical and enzymatic processes, (2) to develop methods for producing alcohols from wood carbohydrates, and (3) to assess methods for improving lignin and other wood by-products to the point at which they can be used in place of petroleum either as direct additions to refinery feed streams or as industrial chemicals or feedstocks.

New Initiatives for the Assistant Secretary for the Environment and Others

Life Sciences Instrumentation Development

A new initiative, to be composed of both ongoing and new projects, is proposed for developing instruments or measuring techniques for application to problems of interest in the life sciences area. Some critical energy-related environmental and health problems of interest to DOE greatly need to be attacked with new methods. Key constraints to solving these problems are the lack of basic data from which to analyze potential health effects and the lack of understanding of the phenomena that play essential roles in determining the course of events leading to human health and environmental effects. This initiative will develop new data acquisition methods (techniques or instruments) to help fill the gaps in our knowledge and capabilities in these areas. As discussed in the following paragraphs, research efforts will focus primarily on developing laser-related analytical techniques and methods for coal effluent monitoring and measurement.

Laser-related Analytical Techniques. Two laser-related techniques, resonance ionization spectroscopy (RIS) and one-atom detection (OAD), have recently been developed at ORNL. These techniques offer capabilities for selectively detecting every element in the periodic table (except helium, fluorine, neon, and argon) at levels of one part in 10^{12} to 10^{15} or, in special cases, at the level of one part in 10^{19} (i.e., at the limit of detecting a single atom of a given species) in gaseous, solid, or liquid samples. Potential applications of these low-level detection techniques include (1) measuring turnover rates in large environmental pools (e.g., oceanic turnover rates), (2) using tracer materials to study the distribution of energy process effluents, and (3) tracking the distribution and fate of trace materials (e.g., heavy metals or plutonium) in the environment or in man and animals.

Initial efforts in implementing the use of these techniques have focused on the renovation of existing space in Building 5500. By facilitating consolidation of existing RIS efforts, this renovated laboratory space will ensure the most efficient use of available resources, including a newly purchased high-power laser system. Renovations should cost $100,000 to $200,000, and occupancy is expected in early 1980. Concurrently, collaborative programs between in-house and outside researchers will be initiated to develop the techniques needed to apply RIS and OAD to environmental problems. Such programs offer many advantages, such as disseminating information on RIS and OAD to the scientific community, providing opportunities to apply unique outside talent to developing these techniques further, and maximizing the amount of work that can be accomplished within given personnel planning levels.

An example of such a collaborative program is the work that will begin shortly with researchers from the Scripps Institution of Oceanography. This project seeks to determine the role of the oceans as a major sink for atmospheric CO_2, which controls the trapping of infrared radiation from the earth's lower atmosphere. Information will be sought concerning the circulation or mixing times of ocean water because the transfer of water from surface to deep ocean appears to be a controlling factor in atmospheric CO_2 concentrations. Consequently, temperatures and climate should likewise be highly sensitive to oceanic turnover rates. This study will focus specifically on detecting the naturally occurring radioactive isotope of argon, ^{39}Ar, at the level of single atoms. This element, which has a half-life of 270 years, is an extremely attractive candidate for determining the length of time since a sample of ocean water has been exposed to the atmosphere.

In addition to the renovations already described, plans under this initiative include establishing a user-

oriented low-level measurement facility that would use the RIS and OAD techniques. At this facility, ultra-low-level counting of radioisotopes would be performed using RIS techniques; ultra-low-level counting of stable isotopes would also be possible using mass spectrometry coupled with RIS. The facility would be staffed and operated by ORNL and would be used to perform measurements desired by various in-house or outside investigators after approval by a review/selection committee. The need for core funding that would allow facility operation without charges to the users will be discussed with DOE, EPA, and the National Science Foundation (NSF). Additional space in Building 5500 is sufficient for the new facility to be colocated with the recently renovated laser laboratory space. The additional renovations to Building 5500 would cost about $0.5 million to $1 million, and the annual operating expenses would be approximately $0.5 million. It is hoped that planning and construction of the facility can begin in FY 1980 and operation during FY 1982.

Coal Effluent Measurement and Monitoring. Several ongoing and new projects are aimed at developing instrumentation for detecting and measuring effluents from coal combustion and conversion. The following projects are generally supported by the Assistant Secretary for the Environment (ASEV) through Subactivity GK 01 02. In some cases, however, additional support will be sought through DOE or other agencies to enable full development of each concept.

A project using derivative ultraviolet absorption spectroscopy (DUVAS) for detecting various emissions resulting from coal utilization is currently under way. During FY 1980, prototypes of this instrument will be constructed and used for workplace monitoring at various coal gasification demonstration facilities. We hope to transfer this technology to interested industrial organizations during FY 1981; interest in the system has also been expressed by several DOE Energy Technology Centers.

Another project in this new initiative will examine the feasibility of using room temperature phosphorescence (RTP) for near-real-time monitoring of polynuclear aromatic (PNA) compounds in particulate matter. The development of an RTP instrument capable of performing on-line area monitoring of airborne PNA compounds would be a major step in creating effective industrial hygiene capabilities for coal conversion plants. A joint program with EPRI for developing this as an ambient air monitor is planned for FY 1980 and FY 1981. If instrument development is successful, feasibility tests will be conducted in FY 1981 and FY 1982, field demonstrations in FY 1982 and FY 1983, and commercialization in FY 1984.

Two other instruments for detecting PNA contamination are also being developed. One, the portable fluorescence spotter, will be used to detect PNA contamination on work-place surfaces. Field testing of two completed units is scheduled to begin at selected coal liquefaction facilities during FY 1979 and FY 1980, and industry will be contacted in FY 1981 concerning further development. The second instrument, the light pipe luminoscope, will be used to detect PNA contamination on skin by means of low-intensity, long-wavelength ultraviolet light transmitted to a stethoscopic cap pressed against the skin. Initial development of this instrument is planned through a joint program with the National Institute of Occupational Safety and Health (NIOSH). Feasibility and field tests should be performed during FY 1980 and FY 1981, and commercialization will follow in FY 1982.

Another program is under way to develop methods for monitoring fossil energy conversion plant personnel for exposure to or uptake of PNAs. During this planning period, the program will examine methods for determining the activity of the enzyme systems involved in the metabolism of PNAs introduced into the human system. The induction of enzyme activity varies with the type and amount of PNA to which the cells have been exposed and thus can be used to monitor cellular exposure.

Finally, large point sources for energy conversion may result in the modification of natural mutation rates in human and/or animal populations near the plant. A system to monitor such rate changes using high sample-throughput methods capable of detecting minute changes in proteins (i.e., single amino acid substitutions) will be developed during FY 1980 and FY 1981. Field testing of this system is expected during FY 1981 and FY 1982, and transfer of the technology to industry is slated for FY 1982 through FY 1984.

Site-Specific Gasification and Liquefaction Studies

As part of its charter to develop new energy sources, DOE has stressed the conversion of coal to gaseous and liquid fuels. However, the production and use of these fuels could result in occupational

exposure and effluent release to the environment. Characterization of these effluents is required to evaluate their potential environmental and health impacts. Sample collection, on-line monitoring, and subsequent analysis and testing are needed to provide data by which the environmental acceptability of the various proposed gasification and liquefaction technologies can be assessed. Also needed are environmental control systems to minimize effluent releases and engineering control systems to minimize fugitive emissions. Information on the efficiency of these systems in reducing releases as well as on their operating costs and maintenance requirements must be obtained.

At DOE's request, ORNL is preparing program plans for investigating selected gasification and liquefaction processes by onsite monitoring of coal conversion facilities as they are built. The objective of this program is to provide the additional data on coal conversion that will permit DOE and other federal agencies to judge the potential environmental and health impacts and the consequent environmental acceptability of proposed conversion processes. The onsite measurements will be evaluated by ORNL, which offers multidisciplinary expertise through its Life Sciences Synthetic Fuels Program. The information thus generated, though site specific, will lend guidance on program modifications or additions at many installations.

Although this new program should be applicable to all potential conversion processes, it will initially be directed (through the Gasifiers in Industry programs) at the evaluation of two low-Btu gasifiers currently planned for construction. These include one at the University of Minnesota—Duluth (UMD) and one at Pike County, Kentucky. The program developed for evaluating the UMD gasifier is characteristic of the approach that will be applied to the evaluation of any coal conversion facility. It involves (1) examining the industrial hygiene of the facility, (2) evaluating the efficiency of the environmental control technology used, (3) investigating the environmental fate and effects of the process effluents, (4) evaluating the potential impacts of product use, and (5) preparing an overall assessment of the health, safety, and environmental impacts of the facility.

DOE has requested that similar investigations be performed for the H-Coal pilot plant now under consideration. No full-scale environmental field program is planned at any of the Gasifiers in Industry sites or at the H-Coal plant. Such studies have, however, been proposed for the SRC demonstration site. Initial efforts in this program must be undertaken as early as possible (perhaps two years before construction begins), and the studies must continue throughout the operation of the demonstration facility. Costs for these efforts are reflected in the budgets for FY 1980 and beyond. Also, an environmental study is planned in cooperation with TVA at their Ammonia from Coal Project demonstration site. In this project, a Texaco coal gasifier is used to produce the feed materials necessary for the synthesis of ammonia for use in fertilizer production.

The studies delineated for this initiative will require support for the investigation associated with each site as well as increased funding for the core effort of the Life Sciences Synthetic Fuels Program. The estimated resources required from ASEV are identified in the following table.

Summary of resources – Site-Specific Gasification and Liquefaction Studies[a]

	'79	'80	'81	'82	'83
Operating cost	1.9	4.0	4.6	2.8	1.9

[a]Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 and FY 1983 is in millions of constant 1981 dollars. Year of expenditure is strongly dependent on individual project schedules.

National Environmental Research Parks

The establishment of certain federal lands as National Environmental Research Parks (NERPs) is an outgrowth of the National Environmental Policy Act of 1969, which has demonstrated the need for and the value of long-term studies related to the environmental impacts of technology. The objectives of NERPs are (1) to develop methods for the continuous quantitative assessment of the environmental effects of man's activities, (2) to develop models to predict the response of environmental components to proposed technological activities, and (3) to provide landscapes representative of the ecological systems found in particular U.S. regions that can be used as regional reference and research sites. Thus, the NERP can serve science and technology as a protected, controlled outdoor laboratory for environmental investigations. Four

such parks have already been designated at DOE facilities (Savannah River, Los Alamos, Idaho Falls, and Hanford).

In 1977, the Environmental Sciences Division of ORNL prepared a proposal to designate certain lands within the Oak Ridge Reservation as an NERP. This proposal was approved and forwarded to DOE by ORO and is being reviewed at Headquarters by several of the Assistant Secretaries. The benefits to ORNL environmental research outlined in the proposal remain—namely, to ensure both the continuity of selected land and water resources areas within the reservation and the continued preservation of undisturbed, natural lands protected from external influences and to protect unique biological areas, as well as rare and endangered species. Most importantly, the existence of an NERP and the activities associated with it would provide a long-term frame of reference in which to interpret the many results of short-term research.

With current DOE support for the park project, ORNL staff are documenting the natural resources of the proposed NERP, developing plans for long-term monitoring networks, and coordinating in-house environmental research with other activities (e.g., timber management and facility construction). Designation of selected reservation land as an NERP would require only modest increases in support. It would, however, facilitate (1) the establishment of monitoring networks to identify effects of technological activities and to document long-term biological trends; (2) the development of a data storage and retrieval system for all environmental data, which would provide review capability; and (3) the monitoring of research by offsite participants.

Summary of resources – National Environmental Research Parks[a]

	'79	'80	'81	'82	'83	'84	'85
Operating cost	0.1	0.2	0.2	0.2	0.2	0.2	0.2
Direct FTE	2	3	3	3	3	3	3

[a]Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. Personnel numbers are in full-time equivalent (FTE) person-years.

The Carbon Dioxide Problem

The increased use of fossil fuels and changes in land use practices (especially deforestation) are contributing to an increase in the atmospheric concentration of CO_2, which has given rise to national and international concern. When the atmospheric CO_2 concentration reaches some currently unknown level, the resulting "greenhouse" effect will lead to significant changes in the earth's climate. These changes will, in turn, affect land use in several important, even vital, ways. Because a substantial increase in fossil fuel use is proposed for the coming decades, we must develop a good understanding of the global carbon cycle. Three critical questions have been posed: (1) How is carbon distributed in the biosphere? (2) What climatic changes could result from CO_2 buildup? (3) What would be the environmental impacts of these changes?

We have proposed to DOE's Office of Health and Environmental Research that ORNL contribute to a broad-based program of research and assessment of the CO_2 problem. A comprehensive R&D program has been funded by NSF as part of an ongoing program in ecosystems science. To support the DOE CO_2 assessment, research in the following four areas is proposed during FY 1979 through FY 1984:

1. Modeling the carbon cycle in the biosphere. We already have extensive experience in terrestrial ecosystem analyses and are a source of much of the needed data. In addition to continuing these terrestrial studies, we shall initiate new research to obtain missing parameters such as rates of land use change, which will be determined by analysis of remotely sensed data, and rates of CO_2 efflux from soil following disturbance.

2. Climatological modeling. Our major development efforts here will be to couple biological responses to climatic change and to reconstruct past climatic variation and associated biospheric response.

3. Impact research and assessment. Although there is very little concerted effort in this area now, we propose to play an increasingly major role, drawing from our extensive experience in impact studies. Particular emphasis will be given to risk analysis of CO_2 buildup and to sensitivity analysis of those parameters in the model whose values may be uncertain. We propose to provide DOE with scientific assessments of key issues on a schedule consistent with its milestone for a complete assessment of the CO_2 problem in FY 1984.

4. Critical data management. We propose to establish and operate a numeric and bibliographic data management system for DOE and its contractors.

Summary of resources – The Carbon Dioxide Problem[a]

	'79	'80	'81	'82	'83	'84	'85
			Approved				
Operating cost	0.2	0.2	0.2	0.3	0.3	0.3	0.3
Direct FTE	3	3	3	3	3	3	3
			Proposed				
Operating cost		0.9	0.9	1.2	0.8	0.8	0.8
Direct FTE		11	11	13	8	8	8
Total cost	0.2	1.1	1.1	1.5	1.1	1.1	1.1
Total FTE	3	14	14	16	11	11	11

[a]Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. Personnel numbers are in full-time equivalent (FTE) person-years.

Nonnuclear Solid Waste Management

The goal of this program is to ensure the safe, economical, and environmentally acceptable disposal of nonnuclear solid wastes, especially those generated in the emerging coal technologies. In addition, some attention is being given to fluidized-bed combustion wastes, as well as to bottom ash, fly ash, and scrubber sludge from conventional coal-fired power plants. Initial efforts (FY 1979 through FY 1981) include the characterization of various solid wastes with respect to their chemical stability and physical properties and an assessment of the potential health and environmental effects of the dissolution products emanating from the various types of nonnuclear solid wastes. Further efforts will involve characterizing the wastes from the leading coal conversion processes to evaluate the influence of pH, redox potential, and surface area of the wastes on the quantity of toxic materials extracted. The effectiveness of clay minerals and soils from representative landfill sites in attenuating the transport of toxic materials from these wastes will also be tested.

In experiments such as these, leachates are used to determine the potential teratogenic, mutagenic, and carcinogenic characteristics of the solid wastes. Significant expertise in this area has been developed at ORNL through a program sponsored by EPA in which we are evaluating solid-waste leaching protocols intended as recommended procedures for testing toxicity compliances with the Resource Conservation and Recovery Act (RCRA). Processing solid wastes for removal (resource recovery) and/or fixation of toxic components is an important option in waste management, and ORNL has experience in processing coal-derived ashes through studies sponsored largely by DOE's OBES.

In addition, we have been given the task of monitoring the development of RCRA for ASEV and developing an analysis of the policy implications for DOE. Current Laboratory efforts also include developing mechanical, chemical, and biological processes by which useful resources could be recovered from solid wastes before disposal or the volume of disposable waste could be reduced.

In support of this new initiative, a facility is planned that would enable laboratory and pilot-scale testing of waste materials. This facility, which would use lysimeters, or waste/soil columns, would allow performance of tests leading to the development of design criteria meeting RCRA specifications for solid waste disposal at future commercial plants. Data obtained at this facility would define monitoring methods and techniques necessary to verify the environmental impact of these solid waste disposal operations.

Included in the facility would be about 20 lysimeter cells equipped with rainfall simulators and instrumented to measure pH, Eh, and the production of volatile gases as well as saturated and unsaturated groundwater flows. Application for funding to initiate the conceptual design of the facility is expected during FY 1980; completion, at a total estimated cost of $5 million, is tentatively scheduled for FY 1985. Ten to twelve FTEs will be required for operation.

Biological Utilization of Waste Resources for Energy Conservation

The objective of this new initiative is to develop an energy-conserving advanced waste treatment system for temperate climates that produces usable biomass. The basic idea is to develop a system that uses the natural efficiency of biological systems to remove nutrient and trace metal contaminants and also provides for the use, in various applications, of the biomass produced in the process.

The system currently under development is a closed-cycle, energy-conserving system that uses harvestable aquatic plants as nutrient scavengers to effect tertiary wastewater treatment. The biomass produced would be combined with the sludge obtained after primary wastewater treatment and subjected to anaerobic digestion to produce methane gas. The methane would be used (1) to provide supplemental heat to optimize plant growth, (2) to

maintain favorable temperatures for the digestion process, and (3) to provide power for other facility functions.

The possibility of a joint project in this area has been discussed with TVA. ORNL would perform the basic research on species and process condition optimization to provide the information necessary to design the proposed system and would subsequently develop a system design. On completion, TVA would consider constructing the pilot plant as part of its Innovative Waste Treatment Development Program.

Summary of resources – Biological Utilization of Waste Resources for Energy Conservation[a]

	'79	'80	'81	'82	'83	'84	'85
ORNL	0.1	0.3	0.5	0.7	0.5	0.3	0.3
Subcontracting and procurement	*	0.1	0.2	0.2	0.1	0.1	0.1
Direct FTE	1	4	5	9	6	3	3

[a]Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. An asterisk indicates funding of less than $50,000. Personnel numbers are in full-time equivalent (FTE) person-years.

Biotechnology Development

Biological processes offer great promise for both near- and long-term production of fuels, as well as for the abatement of pollution and the recovery of valuable resources. However, if such biotechniques are to be practically and economically viable, the engineering and biological processes involved must be optimized. ORNL possesses the expertise in chemical processing and engineering and the biological and environmental sciences to contribute significantly toward developing efficient bioprocesses for the production of fuel, treatment of wastes, and recovery of valuable resources.

During this planning period, three major areas of concentration are envisioned in this initiative. The first of these—bioengineering research—is directed toward the design of practical engineering units for using the biological processes developed in other areas of the program. This area will involve (1) design and development of high-resolution separation techniques for various biological materials; (2) investigation of the immobilization of whole-cell, enzyme, or organelle materials on suitable solid supports or in compatible fibers or semipermeable membranes; and (3) investigation of the reaction kinetics of these biological materials when immobilized or suspended. These investigations will support the design and optimization of bioreactors.

The second major area of concentration, advanced instrumentation, will be directed to the development of instrumentation to measure and monitor important parameters in bioprocesses or to define environmental and human exposure to energy pollutants. This effort will concentrate on examining those biological or biochemical indicators in bioprocesses or in environmental and human systems that are produced as a result of exposure to energy-related pollutants. Of particular interest will be efforts to identify biochemical indicators of mutagenesis in humans.

The third major area of concentration will be bioprocess development. The potential of various bioprocesses in environmental control technology, biomass use, and resource recovery will be investigated. This will involve determining which organisms or plant species are most efficient for a given process, which conditions are optimal for a given organism or biological process, and which conditions are optimal for mass culture of the most efficient organism.

In addition, ORNL is sponsoring, with DOE, a series of symposia to bring together the various disciplines and institutions involved in the development of new bioprocesses for energy production and conservation.

New Initiatives for the Nuclear Regulatory Commission

Ongoing programs in thermal hydraulics, solid mechanics, cladding performance, instrumentation, and information support may be extended and revised to address the data needs identified by studies related to the Three Mile Island incident. New programs are expected in the following areas: advanced simulators for operator training, accident control instrumentation, computer assistance for operation (upset analysis), reactor dynamics model development and verification, advanced containment and decay heat removal, cooling of disrupted cores, fission product control, remote handling and operations, primary-system integrity, and information systems.

Summary of resources – Biotechnology Development[a]

	'79	'80	'81	'82	'83	'84	'85
Bioengineering Research							
Environment							
Operating cost	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Direct FTE	5	5	5	5	5	5	5
Energy Technology							
Operating cost	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Direct FTE	2	2	2	2	2	2	2
Office of Energy Research							
Operating cost	0.3	0.4	0.4	0.4	0.4	0.4	0.4
Direct FTE	3	4	4	4	4	4	4
Solar Energy Research Institute							
Operating cost	0.1	0.2	0.3	0.5	0.5	0.5	0.5
Direct FTE	1	2	3	5	5	5	5
Advanced Instrumentation							
Environment							
Operating cost	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Direct FTE	7	7	7	7	7	7	7
Energy Technology							
Operating cost	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Direct FTE	2	2	2	2	2	2	2
Bioprocess Development							
Energy Technology							
Operating cost	0.8	0.9	1.0	1.0	1.0	1.0	1.0
Direct FTE	8	8	10	10	10	10	0
Environment							
Operating cost	0.2	0.2	0.3	0.3	0.3	0.3	0.3
Direct FTE	2	2	3	3	3	3	3
Conservation and Solar Applications							
Operating cost	0.3	0.4	0.5	0.5	0.5	0.5	0.5
Direct FTE	2	4	5	5	5	5	5
Resource Applications							
Operating cost	0	0.2	0.2	0.3	0.3	0.3	0.3
Direct FTE	0	2	2	3	3	3	3
Total cost	3.1	3.7	4.1	4.4	4.4	4.4	4.4
Total FTE	32	38	43	46	46	46	46

[a]Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. Personnel numbers are in full-time equivalent (FTE) person-years.

Summary of resources – Nuclear Regulatory Commission[a]

	'81	'82	'83	'84	'85
Operating cost					
Reactor Safety Research	3.0	6.0	6.0	4.0	3.0
Office of Nuclear Reactor Regulation	1.0	1.0	0.5	0.3	0.3
Office of Nuclear Materials Safety and Safeguards	*	0.4	0.5	0.5	0.5
Direct FTE					
Reactor Safety Research	25	50	50	30	20
Office of Nuclear Reactor Regulation	12	11	5	3	3
Office of Nuclear Materials Safety and Safeguards	†	5	6	6	5

[a]Funding is in millions of constant 1981 dollars; an asterisk indicates funding of less than $50,000. Personnel numbers are in full-time equivalent (FTE) person-years; a dagger indicates less than 0.5 direct FTE.

New Initiative for the Department of Defense and the Environmental Protection Agency

Carcinogenicity and Toxicity of Diesel Emissions

The potential for energy conservation through increased use of diesel power has recently become apparent. The objective of this new initiative is to investigate the toxic and carcinogenic potential of diesel emissions in order to provide the information necessary to assess the health implications of increased use of diesel power. The programs described below are being supported by EPA and the Department of Defense (DOD) during FY 1979 through FY 1981 and are complementary to efforts being supported by ASEV under GK 01 02 02 1, Health Effects Research in Biological Systems—Carcinogenesis; GK 01 02 02 2, Health Effects Research in Biological Systems—Mutagenesis; and GK 01 02 02 3, Health Effects Research in Biological Systems—Systems Damage. Although details are not yet available, DOE programs in this area are expected to grow significantly in the next year.

Carcinogenicity of Diesel Emission Fractions in Skin-Tumor-Sensitive Mice—EPA. In this project, seven diesel emission samples will be bioassayed for their ability to act as tumor initiators, tumor promoters, cocarcinogens, and complete carcinogens.

Whole Mammal Mutagenicity and *Drosophila* Testing for Diesel Exhaust Studies—EPA. Two efforts will be undertaken in this project. First, the effectiveness of inhaled whole diesel exhaust in inducing heritable effects in a mammal will be studied by a battery of tests on mice. Second, the *Drosophila* sex-linked recessive lethal assay will be used to determine the level of inherited damage in a higher organism as induced by diesel fuel emissions and compared with gasoline automotive emissions.

Chemical Characterization and Toxicological Evaluation of Airborne Mixtures—DOD. The portions of this project applicable to diesel emissions evaluations are twofold. First, the chemical components of airborne smoke (obscurant) produced by volatilization and condensation of diesel fuel No. 2 under field conditions will be determined, and the biological effect on mammals of acute and subchronic whole-body exposures to that smoke under field conditions will be assessed. Second, the *Salmonella* histidine reversion bioassay tests will be used to determine the mutagenic potential of the diesel fuel emissions used in the whole-animal exposure tests.

Summary of resources – Department of Defense and Environmental Protection Agency[a]

	'79	'80	'81
EPA			
Operating cost	0.3	0.4	0.45
Direct FTE	5	5	5
DOD			
Operating cost	0.1	0.2	0.2
Direct FTE	1	2	3
Total cost	0.4	0.6	0.65

[a]Although the programs are expected to continue beyond FY 1981, resource estimates are available only for FY 1979 through FY 1981. Funding is in millions of current dollars. Personnel numbers are in full-time equivalent (FTE) person-years.

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Personnel Resources

ORNL is one of the largest scientific and technological multiprogram laboratories in the world. Among the Laboratory's strengths is the diversity of its technical staff. Forty percent of the personnel are college graduates, of whom more than 850 hold the Ph.D. degree. There are about 700 engineers, primarily chemical, electrical, and mechanical; about 40 mathematicians; 450 physical scientists; and more than 300 biomedical and environmental scientists. There is also a growing staff of economists and other social scientists that currently numbers more than 40.

The Laboratory population also includes about 500 guest scientists on assignment for periods ranging from a few months to a year or more. About 100 of these scientists represent foreign laboratories or research centers; among the others are university faculty and scientists from U.S. industry and government. College and university visitors under a variety of research participation and advanced study programs, most of whom spend between a few days and several months at the Laboratory, number about 1200 annually. This number includes participants in ORNL's University Relations Programs (about 750 in 1978) as well as Oak Ridge Associated Universities (ORAU) contractors and ORNL consultants from the university community.

In addition to ORNL technical staff and guests, the Union Carbide Corporation, Nuclear Division (UCC-ND), central organizations serving all three installations have a general engineering staff of 1275 and a computer sciences staff of 780 available to contribute to ORNL research efforts. Currently, ORNL uses about 350 of the available engineering staff and 200 of the computer sciences staff. ORNL programs located at the Y-12 Plant use 1000 of the 6000 service and support staff located there and an additional 300 from central services groups.

Personnel Trends

As discussed earlier, in the chapter entitled "Laboratory Trends and Issues," the Laboratory's population declined rapidly from 1968 to 1974. Following that period and the subsequent creation of, first, the Energy Research and Development Administration (ERDA) and, later, the Department of Energy (DOE), the Laboratory grew strongly. The number of employees at ORNL, under existing planning levels, should remain essentially constant over the next few years (Fig. 1). Several notable trends in personnel resources projected at ORNL are (1) a substantial increase in subcontracting to universities, industries, and other laboratories; (2) a shift from nuclear to nonnuclear work in basic physical and life sciences research; (3) an increase in personnel involved in coal-related research and development (R&D); (4) an increase in program management for DOE; and (5) an increase in technical staff working on assessments and studies (e.g., policy studies) and in information services.

In recruiting, ORNL has an overall acceptance rate of 45%, an acceptance rate for Ph.D.'s of 63%, and an acceptance rate of 33% for B.S./M.S. candidates. Most of the personnel currently being hired are young; consequently, the average age at the Laboratory has been dropping about one year per

year in recent times. The Laboratory has had some difficulty recruiting people in engineering disciplines because the demand for engineers (mainly from oil companies but also from other industrial R&D laboratories) is high. Reflecting the current planning levels, the number of personnel being recruited for employment is down in both engineering and nonengineering fields. However, the ratio of engineers recruited to the total number of personnel recruited is up from last year. The current turnover rate may be affected by the elimination of the mandatory retirement age of 65. Despite leveling, the Laboratory will continue to pursue in policy and practice its strong commitment to affirmative action.

Personnel Requirements

As stated, under existing guidelines [5150 full-time equivalents (FTEs) in 1979 and 5180 in 1980 and 1981], personnel levels at ORNL should remain essentially constant over the next few years, increasing slightly (about ½% per year) during the second half of this planning period. In 1979, the work force totaled about 5000—2320 direct FTEs and 2680 indirect FTEs. By 1985, ORNL aims (within DOE planning levels) to reach a total of 5280 FTEs, of which 2630 will be direct FTEs and 2650 indirect FTEs. Declines in nuclear work (including work for the Nuclear Regulatory Commission) will be accompanied by growth in coal-related programs. Continuing shifts in the sciences must be accomplished, as in the past, within nearly constant personnel levels. ORNL will continue to use the very strong capabilities of UCC-ND in procurement, computing, contracting, and engineering support. However, any large new technological undertakings will certainly require the addition of special capabilities and some relaxation of personnel planning levels.

Several trends in ORNL personnel resources are expected to continue. The Laboratory plans a substantial, continued increase in R&D subcontracting to industry, universities, and other laboratories—an increase that could rise to a self-imposed limit of 30 or 35% of the Laboratory's total funding. Nuclear-related activities at the Laboratory will decline compared with other programs (fossil, fusion, environment, and basic physical sciences). Further personnel increases are anticipated in the coal area as well as in studies and assessments and in program management for DOE. Although ORNL's conservation program should continue to grow in funding and program management, few additional in-house people will be required. In the Work-for-Others area, the proportion of direct FTEs involved in non-DOE work is projected to decrease, especially during the first half of this planning period.

Although the Laboratory's total of FTEs is projected to increase by about ½% per year during the second half of the planning period, the level of indirect FTEs will be held constant. Consequently, the level of direct FTEs, which include primarily scientific and technical personnel, will increase by about 1%. To support this 1% growth in direct FTEs without increasing overhead and indirect staff, ORNL plans to maintain and increase its operating efficiency in order to use its valuable human resources most wisely.

During this planning period, two factors could affect ORNL personnel resources: (1) the plateau of DOE funding in basic life sciences research and the consequent need to maintain work for other agencies in this important R&D area and (2) the instability of DOE funding in the coal programs, an area in which ORNL is projecting continued growth.

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Site and Facilities Development

One of the major considerations of institutional planning is the future of the facilities resource. The continuing utility of facilities cannot be ensured unless plans for modifying, updating, or constructing facilities are implemented before old facilities fail or new facilities are required by the technical work. This chapter of the *Institutional Plan* addresses this planning area, which is crucial to maintaining the Laboratory's physical capability to carry out Department of Energy (DOE) missions.

Intense efforts are being made to redirect and reassign existing facilities to answer new program requirements as well as to maintain continuity for ongoing programs. Severely limited general plant project (GPP) and operating funds are being used, where possible, for the refurbishment and updating of facilities to meet essential short-term program needs. For the longer term, however, we are relying on the eventual approval of large, expensive line-item projects for the provision of both general-purpose facilities (GPF) and specific programmatic facilities.

Laboratory Site Development

The changing nature of the Laboratory's work, requiring the accommodation of new, different capabilities, is creating significant demands on plant utilities and services. Other pressures have significantly affected office housing, materials stores, food services, and other plant and operational support activities.

To evaluate properly these planned and proposed needs in terms of project requirements versus overall plant capability, the ORNL Master Plan was updated during FY 1979: the new version will be published shortly. Its overall objective is to establish a flexible long-range plan providing for the orderly development of the Laboratory's physical facilities. The Plan is based on management objectives and on program requirements anticipated over the next five years and longer and will serve both Laboratory management and DOE as an instrument for improving the effectiveness and efficiency of operating and planning future facilities. To assist with this effort, an outside consultant with specialized experience in facility planning for research institutions was retained. All facets of facility operations and planning were examined to identify key problem areas and to develop optimized solutions. In particular, timely issues involving environmental protection, waste management activities, and energy conservation were emphasized. The interactions of various divisions and operational functions were also examined in order to identify the relocations and consolidations necessary to improve efficiency and to make laboratory space available to new program experimental needs.

ORNL is one of nine major laboratories whose facility deficiencies are addressed in a draft report to the Office of Construction and Facilities Management of DOE.[1] This report provides an assessment of the adequacy of the general-purpose physical plants

[1] *Multi-Program Laboratory General Purpose Facility Report, FY 1980 through 1984,* September 1978.

in accommodating the laboratories' assigned missions in a reliable, cost-effective manner.

For ORNL, correction of the deficiencies is proposed through 16 line-item projects totaling about $79 million (see the following table). Ten of the projects provide for upgrading 86,800 m^2 (934,000 ft^2) of building space, replacing 21,000 m^2 (225,000 ft^2), and adding 21,400 m^2 (230,000 ft^2). Five cover the upgrading of utilities, and one pertains to roads and parking lots. Of the sixteen projects, four have been included in ORNL budget submissions to date.

As noted previously, increased attention is being directed to radioactive waste management activities at the Laboratory. Four ORNL projects in various stages of study, design, construction, or commissioning can be identified. The Intermediate-Level Waste Facilities Modification Project will be completed during FY 1980. The new Hydrofracture Facility is scheduled for completion at the end of FY 1981, the Improvements to Radioactive Waste Facilities Project in FY 1984, and the Solid Waste Processing Facility (SWPF) in FY 1988. The

Proposed line-item projects

Project title	Total estimated cost (millions of dollars)	Starting date proposed by ORNL (FY)
Energy Systems Research Laboratory	20.0	1981, 1982[a]
Upgrade ORNL Primary Substation	3.5	1981
Materials Warehousing Upgrade	3.3	1982
Information Resource Center for Energy and the Environment	11.0	1982
Primary Electrical Distribution System Restoration	2.5	1983
Central Chilled Water System Restoration	2.0	1983
Renovate HVAC Systems in Four Heavy Engineering Laboratory Facilities	21.8	1983
Primary Water Mains Restoration	4.4	1984
Alternate Water Supply	2.7	1984
Maintenance Facilities	4.9	1984
Machine Shop Facilities	6.0	1984
General Engineering Facility	5.5	1985
General Laboratories Replacement	7.6	1985
Multiprogram Support Shop Facilities	1.4	1985
Personnel Service Facilities	1.4	1985
Main Laboratory Access and Parking	1.4	1985

[a]About $2 million will be spent in 1981 for architect-engineering design work; the remaining $18 million will be spent for construction, which is scheduled to start in 1982.

Additional items will be included in future budget submissions, based on guidance from the General-Purpose Facility Review, and, of course, other proposals for GPF of various kinds are being made.

In Table B.13, Appendix B, three categories of line-item construction projects are identified for this planning period. Included are ongoing construction projects, budgeted new construction projects, and proposed projects not yet included in a budgetary process. A brief description and justification for each of the projects in the second and third categories follows.

information obtained during the planning, design, and operation of these facilities will benefit the overall Radioactive Waste Management Program in its new role in implementing low-level radioactive waste management programs at DOE and other federal installations.

Programmatic Facilities

Solid Waste Processing Facility

The SWPF will receive low-level, beta-gamma contaminated solid waste generated at ORNL, process it through size-reduction devices, and

pelletize or incinerate it to ash for permanent disposal in the Hydrofracture Facility. In addition, space and processes will be provided to decontaminate low-level contaminated equipment for reuse in ORNL programs or to decontaminate SWPF equipment. The proposed location of the facility is adjacent to an existing ORNL waste disposal area.

The new facility will enable reduction of the land area now being used to dispose of low-level, beta-gamma solid wastes and conversion of the wastes to a less mobile form, which will reduce the risk of inadvertent environmental contamination. Plant engineering and design (PE&D) activities, which are estimated to cost $4.4 million, are planned for FY 1979 and FY 1980. Construction will follow and should be completed in FY 1988. Very preliminary construction cost estimates indicate a total project cost of $33 million.

Upgrading Laboratories to Handle Hazardous Materials

This project proposes the renovation of about 1,100 m^2 (11,500 ft^2) of existing area used for animal research involving hazardous materials. This renovation is required to meet standards now being established for protecting workers' health and the environment in facilities where such experimental work is being conducted. The renovation will also provide facilities, which will meet the new requirements of federal regulatory agencies, for experimental and testing work that is currently impossible because of the lack of adequate facilities. Construction is planned to start in FY 1981 and should be completed in FY 1982; the total estimated cost is $1.5 million.

Improvements to Radioactive Waste Facilities

This project will (1) upgrade and replace ductwork and related equipment in the main cell ventilation and off-gas exhaust stack in the 3039 area that services the whole X-10 site; (2) provide new flow measuring devices and support facilities for monitoring stations located at White Oak Creek, Melton Branch, and White Oak Dam; (3) establish a new Waste Operations Control Center equipped with state-of-the-art electronic and computer control to monitor radioactive waste operations; and (4) replace up to 19 local intermediate-level liquid waste collection tanks with up to six new double-contained tanks. Construction is planned to start in FY 1981. It should be completed in FY 1984 at a total estimated cost of $15.5 million.

High Temperature Materials Laboratory

The major technologies for energy generation or conversion involve high-temperature processes, and their efficiency, reliability, and (for some advanced concepts) feasibility are limited by high-temperature materials problems. Because knowledge of the properties of materials at high temperatures is grossly inadequate, ORNL has proposed a High Temperature Materials Laboratory (HTML) around which a comprehensive and coordinated research program will be established to answer this need. Work in the HTML will encompass both wide-ranging basic research on model systems and investigations of the behavior of the more complex materials commonly used in high-temperature technologies. The laboratory will be organized for a variety of interdisciplinary studies, and interactions with the industrial and university research communities will be encouraged through a users program. Part of ORNL's large inventory of materials-testing equipment will be incorporated into the HTML along with an extensive amount of new equipment. The estimated expenses for building and equipping the HTML are as follows:

	Cost (millions of 1981 dollars)
Building [7,400 m^2 (80,000 ft^2)]	20.0
Equipment and moving	7.5
	27.5

The $7.5 million for equipment and moving expenses is not included in the summary of operating cost forecasts. It is estimated that the HTML staff of about 75 professionals will require a total operating funding of approximately $10 million per year (FY 1979 dollars). About 70% of the operating funds will come from the materials sciences program of the Office of Basic Energy Sciences (OBES) (this will be an expansion of their current programs, now funded at $3 million) and 30% from the applied technologies. We are submitting the proposed HTML as a line item for the FY 1981 budget. Discussions on this proposal have been held with the staff of the Division of Materials Sciences, OBES, and a conceptual design report has been prepared. Design will be initiated during FY 1981 at a cost of $3.0 million.

Construction is scheduled to start in FY 1982; completion is projected for FY 1985 at a total estimated cost of $27.5 million.

Toxic Substances Laboratory and Animal Facility

Specialized laboratories and animal space must be made available for use in investigating acute and chronic effects of products, by-products, or effluents from the nonnuclear energy technologies being developed and assessed as part of the DOE mission to seek alternative methods of energy production. The toxicology study is essential to the future protection of the health of workers, the general public, and, indeed, all animal and plant species. To deal with this task, DOE has recently established a toxicology program in the Biology Division complementary to ongoing programs in mutagenesis and carcinogenesis.

Facility plans for the program include construction of a two-story steel frame and masonry structure; it will contain about 3,100 m^2 (33,500 ft^2) of gross floor area and include an overhead walkway to an adjacent existing building. The structure will house special laboratories for handling toxic materials, rooms for small rodents and larger animals such as dogs, and the support facilities required for operation of the facility. Service roads will be extended. Standard laboratory furniture, office furniture, cage and equipment cleaning facilities, large sterilizers, miscellaneous movable laboratory equipment, animal cages, and racks will be installed. Funding for the new equipment and furniture is included in the project cost estimate. Construction is scheduled to start in FY 1982 and should be completed in FY 1985; the total estimated cost is $16.5 million.

Upgrading of Laboratories, Offices, and Support Facilities of the Fusion Energy Division at Y-12

This project will provide a building addition and the necessary modifications and rehabilitation of existing facilities required to support the growing fusion energy research and development program at the Laboratory installations located at the Y-12 Plant. The World War II electromagnetic separation buildings have been gradually updated over the years, but funds have not allowed systematic upgrading to the standards and capabilities needed in current operations. Because of this, Fusion Energy Division programs are largely conducted in facilities with heating and ventilation systems unsuited to current needs and antiquated electrical and utility systems that require excessive maintenance and periodic renovation. Construction is planned to start in FY 1981; completion, at a total estimated cost of $7.6 million, is projected for FY 1983.

Modernization of Laboratories for Study of Environmental Pollutants

This project proposes to upgrade existing air supply and exhaust systems and renovate selected portions of an existing building that is part of the Biology Division at the Y-12 Plant. Adequate airflow capacities and the treatment of exhaust air from laboratories and animal facilities to remove toxic materials must be provided. The original air-handling systems of this building were primarily designed to supply conventional heating and cooling for laboratories and offices and ventilation for a few chemical hoods. Increased air handling is required to achieve a clean-room laboratory environment for tissue culture and to provide airflows sufficient both to maintain suitable air balance and air pressure differentials and to treat potentially contaminated exhaust air. Construction, scheduled to start in FY 1982, should be completed in FY 1983 at a total estimated cost of $2.1 million.

Accelerator and Reactor Improvement Project (EN Tandem)

To exploit fully the use of Laboratory tandem accelerator facilities for future atomic collisions research, basic improvements that capitalize on the excellent ion sources and instruments available are badly needed. The improvements proposed in this project include the development of a vacuum, in all the beam lines following beam energy analysis, sufficient to maintain the charge-state purity of the heaviest, most highly stripped particles. This capability is important because the ionic charge state is often a critical parameter in interpreting atomic collision phenomena. The beam lines will be modified to ultrahigh-vacuum standards and will include pumping stations with cryopumps, slits, Faraday cups, viewers, and passivated stainless steel beam lines. Compatibility of all instruments transportable between the EN Tandem Van de Graaff Laboratory and the Holifield Heavy Ion Research Facility (HHIRF) will be maintained. Construction is scheduled to start in FY 1981 and should be completed in FY 1983. The total estimated cost is $0.6 million.

Accelerator Improvement Projects (Holifield Heavy Ion Research Facility)

Because of the continuing necessity to accommodate changing experimental needs and to keep pace with advances in technology, yearly incremental funding submissions for accelerator improvements are planned for the foreseeable future. The submissions will consist of those improvements identified and given highest priority by the users of these research facilities. For FY 1981, the project will provide for improvements in the ion source and beam-bunching capabilities of the 25-MV tandem accelerator. Construction is scheduled to start in FY 1982. It should be completed in FY 1983 at a total estimated cost of $0.7 million.

Consolidated Fuel Reprocessing Program Hot Experimental Facility

The Consolidated Fuel Reprocessing Program (CFRP) Hot Experimental Facility (HEF) will be a major component in the development of a fuel reprocessing technology for breeder reactor fuels. The plant will include a receiving and storage facility as well as a complete fuel reprocessing system capable of handling fuels from a variety of fuel cycles.

Authorization and funding is initially being requested only for partial Title I engineering and initiation of Title II engineering. Construction schedules and total estimated costs will be developed as part of this and of future authorized engineering services; construction authorization will be requested in FY 1984. The cost of the project is estimated at about $500 million to $1.0 billion (FY 1978 dollars). Engineering design activities, at an estimated cost of $60.0 million, are scheduled for FY 1981 through FY 1983.

Mutagenesis Screening and Testing Facility for Synthetic Fuels

This project will involve the modification and renovation of about 510 m^2 (5500 ft^2) of existing second-floor area in the ORNL Biology Division complex at the Y-12 Plant. Additional laboratory and associated service space is needed for expansion of an existing program, the mission of which is to assess the health effects of existing and proposed methods of energy generation, especially those associated with coal conversion technologies. Facilities must be provided for rapid testing for mutagenesis by a battery of short-term bioassays (e.g., the Ames test) with nonvertebrate species. Construction is scheduled to start in FY 1982; completion, at a total estimated cost of $1.8 million, is projected for FY 1984.

Mammalian Genetics Facility

This project will include construction of a two-story steel frame and masonry structure containing about 1,400 m^2 (15,000 ft^2) of gross floor area. The building will house not only general- and special-purpose laboratories but also necessary support services, facilities, and storage areas. General- and special-purpose laboratory equipment will be installed along with laboratory and office furniture. Construction of service access driveways will be required.

The need for the facility has resulted from the shift in emphasis in mammalian mutagenesis from ionizing radiation exposure experiments to the study of the health effects of the chemical and physical agents associated with a variety of energy sources (particularly coal conversion processes). This shift has necessitated new experimental methods and laboratory facilities suitable for the safe and effective handling of these chemicals. This specially designed facility will meet these needs and complement the existing mutagenesis and teratogenesis experimental program. Construction is scheduled to start in FY 1983; completion is projected for FY 1985. The total estimated cost is $6.0 million.

Hazardous Waste Incinerator Facility

An efficient, effective, and safe means must be provided for the disposal of waste materials generated by experimental studies of the health effects of the products, by-products, and effluents of developing energy technologies. Major components of this waste include filtration materials from the air-handling facilities serving the experimental facilities and materials that are generated in the treatment and maintenance of experimental animals and may be contaminated with small amounts of potentially hazardous chemicals. Some of these materials are now being secured in drums (at considerable expense) and stored until a satisfactory means of permanent disposal is available. The proposed facility, which will serve all Oak Ridge installations, will be a single-story, high-bay structure of 140 m^2 (1500 ft^2); it will house an incinerator facility with heat recovery capability and the associated utility services, including fuel oil supply and return piping. Construction, scheduled to start in FY 1983, should

be completed in FY 1985. The total cost is estimated at $1.3 million.

Improvements to Engineering Technology Facilities

Because of a lack of funds, the World War II buildings occupied by the Engineering Technology Division at the Y-12 site have inadequate heating and ventilation systems, antiquated electrical and utilities distribution systems, and support facilities and outside utilities that require excessive maintenance and periodic renovation. This project will provide a new and urgently needed storage building, improved and more energy-efficient air-handling systems, upgraded utilities systems, and additional offices. Furthermore, it will upgrade existing office space and will lead to more efficient use of this space. Construction is scheduled to start in FY 1984. It should be completed in FY 1986 at a total estimated cost of $9.0 million.

Chemical Toxicology Facilities

The proposed project will include modification and renovation of about 1,900 m^2 (20,000 ft^2) of the sixth floor of the main Biology Division research facility at the Y-12 Plant. Basically, three functional areas will be provided: an upgraded animal area, a laboratory equipped for low- and moderate-risk toxicological research, and a shower and change room facility. Because the building's existing structural system is at its limits, a new equipment building to house major improvements in the heating, ventilating, and air conditioning (HVAC) system and an incinerator will be appended to the north wall of the existing structure.

The proposed facilities are needed to provide specialized laboratories and animal space for use in investigating the acute and chronic effects of the toxic chemical compounds and metals occurring as products, by-products, or effluents of nonnuclear energy technologies. This investigation will focus on the nonnuclear energy technologies currently being assessed and developed as alternative methods of energy production and will be essential to the establishment of standards for the future protection of the health of workers and the general public. Construction is scheduled to start in FY 1983 and should be completed in FY 1985; the total estimated cost is $13.7 million.

General-Purpose Facilities

Energy Systems Research Laboratory

In recent years, ORNL has grown in staff and programs, especially in nonnuclear areas. Our laboratories often fail to meet current program requirements for height, floor loading, isolation, temperature control, and cleanliness. Office space is insufficient for the current staff: over 800 office users are overcrowded [having less than 7 m^2 (75 ft^2) each], and an additional 1100 are in substandard offices (attics, basements, or trailers; offices that are old, deteriorated, noisy, etc.). The Energy Systems Research Laboratory (ESRL), submitted as a $20 million line item for the FY 1981 budget, will alleviate some of these problems. The new 9,300-m^2 (100,000-ft^2) building will provide space for research laboratories, offices, and service areas. The largest portion of the building will house much of the fossil energy program. The structure will also house most of the geothermal, solar energy, and conservation programs and essentially all of the biotechnology program. Design is to be initiated in FY 1981 at a cost of $2.0 million. Construction, tentatively scheduled to start in FY 1982, should be completed in FY 1985 at a total estimated cost of $20.0 million.

Upgrade ORNL Primary Substation

In order to meet future load growth, maintain a high degree of service continuity, and improve the flexibility and safety of the primary substation, transformer capacity for the ORNL-area power system will be increased. Along with the addition of 40 MVA of electric capacity to the existing primary substation, the project will include construction of security fencing to protect new and existing equipment. Construction is scheduled to start in FY 1981; completion, at a total estimated cost of $3.5 million, is projected for FY 1983.

Water Pollution Control—ORNL (BATEA)

This project will provide facilities for treating effluents from existing ORNL installations sufficiently for discharge to surface streams, or for other means of disposal, in accordance with the "best available technology economically achievable" (BATEA) provision of the Clean Water Act

Amendments of 1977. Included will be (1) major improvements to the main sewage treatment plant; (2) a new sewage treatment plant for the 7900 area; (3) improved sewage treatment capability at the 7600 area; (4) facilities for removing trace heavy metals and suspended materials from, and adjusting the pH of, the coal pile drainage at the steam plant; (5) a new liquid storage facility, equipped with spill control, for oil and hazardous substances; and (6) diking or spill sumps for electric transformers that contain oil or polychlorinated biphenols (PCBs). Construction, scheduled to start in FY 1981, should be completed in FY 1984 at a total estimated cost of $10.0 million.

Energy Management System

Most ORNL facilities were constructed before the energy crisis, when design objectives stressed low capital investment rather than low energy use. Thus, many of the HVAC systems installed were equipped with controls providing continuous operation. However, many areas are occupied only 40 hr per week, and shutting down or minimizing the operation of unneeded equipment during off-hours and weekends would provide significant reductions in energy use. The proposed Energy Management System (EMS) is a centralized computer monitoring and control system that will provide such control for the HVAC systems of five major buildings or portions thereof. Typical monitoring and/or control factors include temperature, pressure, humidity, flow, and equipment start-stop status. The project will effect an energy savings of $652,000 per year, which results in a savings-investment ratio of 2.5 and a discounted payback period of 6.1 years. Construction is scheduled to start in FY 1981 and should be completed in FY 1982. The total estimated cost is $4.0 million.

Environmental and Effluent Monitoring Systems Upgrade

Planned improvements include modernizing existing liquid and gaseous environmental monitoring stations and adding new stations to provide more detailed coverage of the surrounding area. As currently envisioned, station activities will include collecting gaseous and liquid effluent and real-time meteorological data. A new 460-m^2 (5000-ft^2) structure that will serve as a sample preparation laboratory and data-handling facility is also planned. Monitoring information will be transmitted to the Environmental Data Processing Center and to the Laboratory Control Center. Construction, scheduled to start in FY 1982, should be completed in FY 1985 at a total estimated cost of $8.1 million.

Modifications Aimed at Compliance with the Occupational Safety and Health Act

This project specifies additions and modifications necessary to bring ORNL into compliance with provisions of the Occupational Safety and Health Administration Document No. 2206, Part 1910, "General Industry Safety and Health Regulations," June 1974. Construction should begin in FY 1982 and is scheduled for completion in FY 1984. The total estimated cost is $3.8 million.

Materials Warehousing Upgrading

For several years, ORNL's materials management and warehousing programs have operated under the constraints of inadequate and improperly located storage space. Logistic problems have been compounded by the recent expansion of research programs in other areas and by pressures to move from established stores areas. Significant increases in procurement and receiving transactions as well as a larger stores inventory and increased use of stores materials have also worsened the problem. The proposed upgrading will include construction of a covered gas cylinder dock, a stores facility and a warehouse for electronic equipment, and an equipment and materials warehouse and the addition of a roof to an existing 930-m^2 (10,000-ft^2) concrete pad. Construction is scheduled to start in FY 1982; it should be completed in FY 1984. The total estimated cost is $3.3 million.

Improvements in Fire Protection

This project will provide only those fire protection improvements identified by the Factory Mutual Engineering Association and the ORNL Fire Protection Department as necessary to upgrade the Laboratory to a "preferred risk" status. Included will be installation or modification of wet and dry sprinkler systems, installation of Halon-type systems in special areas, changes and additions to electric alarm and annunciator systems, and the addition of ventilation in areas associated with the storage and

handling of flammable liquids. Construction is scheduled to start in FY 1982. Completion, at a total estimated cost of $2.8 million, is projected for FY 1984.

Information Resource Center for Energy and the Environment

The Information Resource Center for Energy and the Environment (IRCEE) will be designed to serve as a center for information and meeting activities for ORNL, DOE, and the southeastern United States. Its planned 7,900 m^2 (85,000 ft^2) of floor area will house a consolidated information center that will allow optimized interaction among information groups, users, workshops, conferences, and training sessions. Included will be an auditorium with a seating capacity of 800 as well as four smaller meeting rooms for groups of 100 to 150 and several small workshop rooms. The latest equipment for audio and visual presentations and for information storage and retrieval will be provided. Construction is scheduled to start in FY 1982; it should be completed in FY 1986 at a total estimated cost of $11.0 million.

Laboratory Control Center

The proposed Laboratory Control Center will provide centralization of both the routine and emergency supervision of ORNL facilities. Because the existing emergency control system is scattered, it is difficult to assess the extent of an emergency. The existing command center is unprotected and undersized and does not receive all necessary emergency data input. The proposed Laboratory Control Center, however, will provide a focal point for a Data Center Complex that will include the emergency control system and command center, the Waste Operations Center, and the Environmental Monitoring Laboratory. All critical process radiation, utility, safeguards, and environmental monitoring alarms will be monitored continuously in the control room of the Laboratory Control Center. Construction is scheduled to start in FY 1982 and should be completed in FY 1984 at a total estimated cost of $2.6 million.

General-Purpose Facilities Beyond 1982

Because long-range planning has been carried out in this area (see ref. 1, p. 97), some longer-term proposals are made for GPF needs during the latter half of this planning period. Brief descriptions of these items (listed by priority within each year) are given in the table on the opposite page.

General Plant Projects and General-Purpose Equipment

The funding for general-purpose equipment (GPE) and GPP has been inadequate for many years, limiting the opportunity to update and renovate old buildings, facilities, and equipment. The problem has worsened over the last decade because GPP funding has fallen very rapidly compared with the other operating costs of the Laboratory (Fig. 11). Current budget submissions from ORNL call for a modest increase in GPP to reverse this trend. ORNL has fared especially badly compared with the other nonweapons multiprogram laboratories.

Automated Data Processing Requirements

The projection of computing capability needed at ORNL and at the other Oak Ridge plants is shown in Fig. 12. The existing batch computing facilities were saturated at the end of 1976; however, installation of a major new system began in FY 1979 and will be completed in FY 1980. The purchase cost of this system would be about $10 million, but the new computers will actually be leased. Besides providing the capability to meet batch work-load requirements, the system will include devices needed to meet on-line storage requirements; in particular, they will allow interactive information retrieval from energy-related data bases.

The current major users of the batch computing facilities at ORNL will still have the largest requirements during the next five years. The greatest uncertainties in the projections arise from the impact of relatively young programs in fields such as environmental and health sciences, coal technology, and information processing that have a large potential for increased computer usage. Currently projected needs and the computer acquisition schedule indicate that there will be no significant computer shortage in the immediate future. In FY 1984, we foresee the need for additional capacity to handle the increasing work load and to provide for the replacement of the IBM 360/91 computer, which will then be 16 years old.

The interactive capability was greatly oversaturated in 1976, but with the addition of a PDP-10 KL10 central processor in FY 1977, adequate interactive computing became available. Although incremental upgrades to the system have been made, it is now saturated again. The relief of this saturation is dependent on the approval of $850,000 of funds requested for FY 1980.

General-purpose facilities for FY 1983 and beyond

Project title	Description	Total estimated cost (millions of dollars)
	1983	
Primary Electrical Distribution System Restoration	Replace deteriorated, obsolete, and unreliable equipment in 13.8- and 2.4-kV systems	2.5
Central Chilled Water System Restoration	Replace three obsolete, unreliable compressors and deteriorated cooling towers	2.0
Renovate HVAC Systems in Four Heavy Engineering Laboratories	Renovate HVAC systems in four heavy engineering laboratory buildings at the rate of one per year for four years	21.8
	1984	
Primary Water Mains Restoration	Replace selected primary water mains	4.4
Alternate Water Supply	Provide alternate to single water supply to X-10 site	2.7
Maintenance Facilities	Replace obsolete, substandard maintainence facilities	4.9
Machine Shop Facilities	Replace and upgrade obsolete machine shop facilities	4.4
General Analytical Laboratory Renovation	Replace radioactive analysis laboratory equipment and restore service systems; renovate work areas	1.4
	1985	
General Engineering Facility	Replace 1946 army-type, wood frame structure	5.5
General Laboratories Replacement	Replace general laboratory facilities now in two Quonset huts	7.6
Multiprogram Support Shop Facilities	Upgrade decentralized research service shops	1.4
Personnel Service Facilities	Replace, expand, and rearrange cafeteria facilities; replace personnel training facility	1.4
Main Laboratory Access and Parking	Correct horizontal and vertical alignment of roads; expand and rearrange parking	1.4

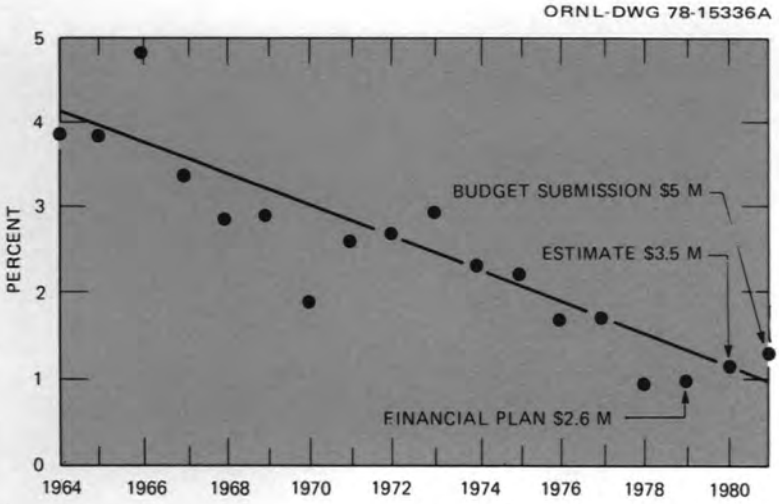


Fig. 11. During the last decade, GPP funding has declined rapidly as a percentage of operating cost.

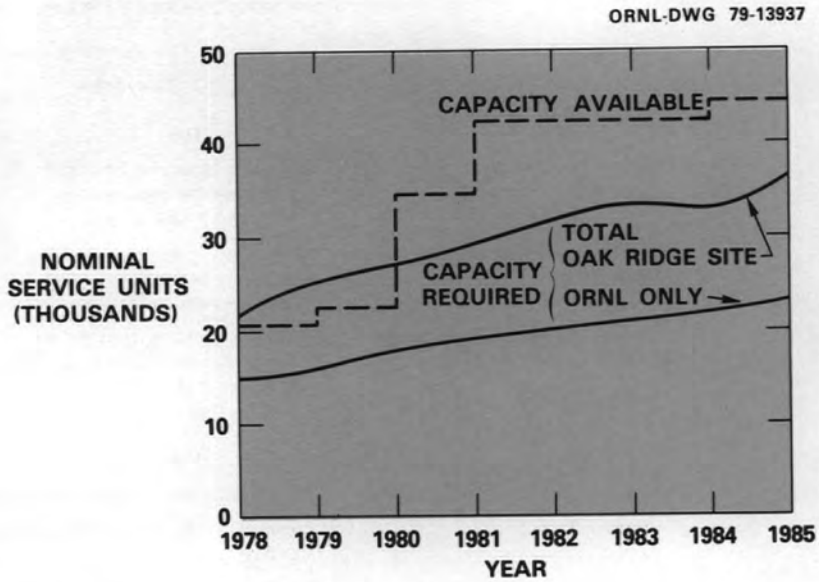
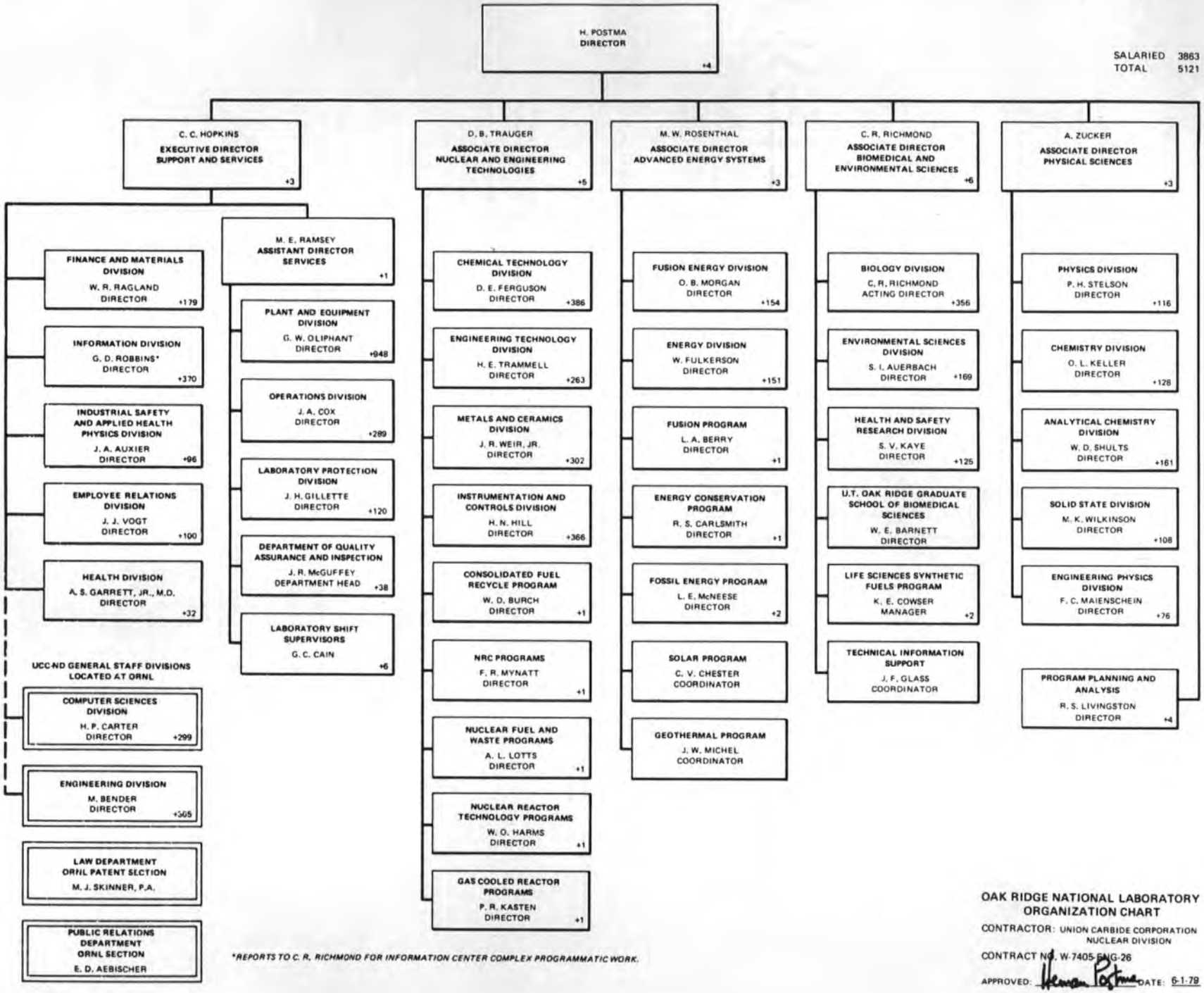


Fig. 12. Currently projected needs and the computer acquisition schedule indicate that there will be no significant computer shortage in the immediate future.

The replacement of the IBM 360/91 in FY 1984 is the only major item currently required. This is complementary to replacements for older peripheral items and incremental upgrades through GPE funding in the intervening years. To ensure continued scientific productivity, it will be necessary to replace and upgrade these items while maintaining older equipment, which will require expenditures of about $300,000 per year.



*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: Herman Postma DATE: 6-1-79

ORNL–DWG 79-18107

ORNL OPERATING STRUCTURE

EXECUTIVE DIRECTOR SUPPORT AND SERVICES		ASSOCIATE DIRECTOR BIOMEDICAL AND ENVIRONMENTAL SCIENCES	ASSOCIATE DIRECTOR ADVANCED ENERGY SYSTEMS	ASSOCIATE DIRECTOR NUCLEAR AND ENGINEERING TECHNOLOGIES	ASSOCIATE DIRECTOR PHYSICAL SCIENCES
		DOE PROGRAMS			
		Environment – Multiresource Basic sciences – Life sciences Hydroelectric	Energy supply research and development – Coal, Petroleum, Solar, Geothermal, Fusion, Biomass Energy supply production – Solar Conservation Energy information – Multiresource Emergency preparedness Policy and evaluation Economic regulatory admin.	Energy supply research and development – Fission Atomic energy defense – Weapons Decommissioning	Basic energy sciences Basic sciences – High-energy physics, Nuclear physics University relations Advanced technology projects Technical Assessments
		ORNL DIVISIONS			
Plant and Equipment Quality Assurance and Inspection Engineering Operations Laboratory Protection	Finance and Materials Health Employee Relations Information – Service Industrial Safety and Applied Health Physics	Biology Health and Safety Research Environmental Sciences Information – Research	Energy Fusion Energy	Chemical Technology Instrumentation and Controls – Research and Services Metals and Ceramics Engineering Technology	Analytical Chemistry Chemistry Engineering Physics Physics Solid State
		OTHER FUNCTIONAL DOE ASSIGNMENTS			
Laboratory Shift Supervisors	Central Management Offices Director's Reserve Liaison: Bargaining units, UCC-ND Engineering, Computer Sciences, UCC-ND Finance, Other UCC-ND installations	Information research and development Environmental Policy Analysis Program Life Sciences Synthetic Fuels Program Health Physics Research Reactor Biotechnology	Fossil energy program Fusion energy program Conservation program Oak Ridge Research Reactor Solar coordinator Geothermal coordinator Energy Systems Research Laboratory	Gas-cooled reactor program Nuclear Reactor Technology Program NRC program Fuel recycle program Bulk Shielding Reactor Tower Shielding Facility Nuclear waste program LWR program UCC-ND Technical Liaison	Chemical Technology – electromagnetic stable isotopes High Flux Isotope Reactor Chemical Technology Transuranium Facility Holifield Heavy Ion Research Facility High Temperature Materials Laboratory
		NON-DOE PROGRAM ASSIGNMENTS			
		Department of Agriculture National Oceanic & Atmospheric Administration Air Force Environmental Protection Agency Department of Health, Education, and Welfare Office of Water Resources Technology United States Geological Survey National Aeronautics & Space Administration National Science Foundation Tobacco Research Tennessee Valley Authority (Environmental) U.T. Biomedical School Library of Congress	Federal Emergency Management Agency Department of Housing & Urban Development Tennessee Valley Authority (Nonenvironmental) Office of Surface Mining Water Resources Council Department of Commerce UT (ACES)	Navy Electric Power Research Institute Arms Control and Disarmament Agency Veterans Administration Nuclear Industry (including Met. Ed.)	Defense Nuclear Agency Army State Department Oak Ridge Associated Universities Gas Research Institute

Table B.1. Summary of Laboratory resources[a]

	'79		'80		'81		'82		'83		'84		'85	
	BO[b]	BA[c]	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA
Funding														
DOE operating funds	235.2	243.0	288.9	291.9	321.4	334.9	347.2	320.1	338.3	339.3	341.5	341.8	347.0	348.4
Non-DOE operating funds	42.3	43.1	46.2	46.2	41.0	41.0	41.2	41.2	42.6	42.6	43.6	43.6	44.6	44.6
Capital equipment (including general-purpose equipment)	16.6	19.4		29.9		40.7		33.2		29.0		30.5		30.7
General plant projects	2.5	3.1		4.8		6.3		6.0		6.0		6.0		6.0
Construction[d]	5.0	9.9		6.4		0		0		0		0		0
Total BA	301.6	318.5		379.2		422.9		400.5		416.9		421.9		429.7
Personnel[e]														
DOE direct[f]		1885		2060		2109		2154		2175		2194		2210
Non-DOE direct		436		460		409		400		407		413		420
Indirect		2680		2650[g]		2650		2650		2650		2650		2650
Total		5001		5170		5168		5204		5232		5257		5280

[a]Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars.
[b]Budget outlay.
[c]Budget authorization.
[d]Budgeted or funded projects.
[e]Personnel figures are in full-time equivalent (FTE) person-years.
[f]Includes isotopes production and sales.
[g]This decrease reflects an accounting change whereby 30 existing staff at ORNL are transferred from overhead accounts to accounts for the waste program.

Table B.2. Summary of resources by secretarial officer[a]

	Fiscal year						
	'79	'80	'81	'82	'83	'84	'85
Assistant Secretary for Energy Technology[b]							
Operating							
BO[c]	129.8	155.0	176.8	198.5	187.7	188.2	190.0
BA[d]	130.0	153.0	188.6	170.8	188.5	189.6	190.7
Subcontracting, BA	36.0	54.1	70.0	74.9	69.1	68.8	69.2
Procurement, BA	19.7	23.5	29.2	31.8	32.0	33.2	34.8
Capital equipment, BA[e]	13.1	20.4	21.0	22.8	18.6	19.8	20.1
Construction, BA	6.0	6.4	0	0	0	0	0
Direct personnel, FTE[f]	769	780	816	833	836	846	853
Director of Energy Research							
Operating							
BO	40.0	45.0	50.2	51.1	52.3	53.7	55.1
BA	40.4	46.6	51.5	51.7	52.8	54.2	55.7
Subcontracting, BA	0.1	0.6	0.8	0.8	0.9	1.0	1.1
Procurement, BA	1.2	0	0	0	0	0	0
Capital equipment, BA	3.3	4.6	5.8	6.4	6.4	6.7	6.6
Construction, BA	0.4	0	0	0	0	0	0
Direct personnel, FTE	497	527	532	539	545	551	557
Assistant Secretary for the Environment							
Operating							
BO	29.6	33.5	35.7	36.8	37.9	38.9	40.2
BA	28.7	34.2	36.5	36.9	37.9	39.0	40.2
Subcontracting, BA	1.8	2.2	2.1	2.1	2.1	2.1	2.1
Procurement, BA	1.6	1.9	1.9	1.9	1.9	1.9	1.9
Capital equipment, BA	1.8	2.7	2.1	2.3	2.4	2.4	2.4
Construction, BA	2.1	0	0	0	0	0	0
Direct personnel, FTE	334	373	379	386	393	400	407
Assistant Secretary for Conservation and Solar Applications							
Operating							
BO	7.9	16.9	16.5	16.5	16.5	16.5	16.5
BA	14.5	17.8	16.5	16.5	16.5	16.5	16.5
Subcontracting, BA	4.3	11.6	11.1	11.0	11.0	11.0	11.0
Procurement, BA	0.1	*	*	*	*	*	*
Capital equipment, BA	0.4	0.6	0.3	0.3	0.3	0.3	0.3
Direct personnel, FTE	44	61	62	63	63	63	63
Other DOE programmatic							
Operating							
BO	9.6	12.9	14.9	15.8	14.1	12.6	12.1
BA	10.8	14.7	14.5	15.7	13.9	12.9	12.2
Subcontracting, BA	3.2	3.3	3.5	3.4	3.4	3.4	3.4
Procurement, BA	1.3	2.4	3.9	3.6	1.8	0.5	0.5
Capital equipment, BA	0.2	0.4	0.6	0.3	0.3	0.3	0.3
Construction, BA	1.4	0	0	0	0	0	0
Direct personnel, FTE	53	70	72	78	80	77	71

[a]Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. An asterisk indicates funding of less than $50,000. Because of rounding, the sum of the individual costs for a given year may not equal the total shown.

[b]Figures exclude DOE reimbursements.

[c]Budget outlay.

[d]Budget authorization.

[e]Including general-purpose capital equipment.

[f]Full-time equivalent (FTE) person-years.

Table B.2[a] (continued)

	Fiscal year						
	'79	'80	'81	'82	'83	'84	'85
DOE reimbursements							
Operating							
BO	18.3	25.6	27.3	28.5	29.7	31.6	33.1
BA	18.6	25.6	27.3	28.5	29.7	31.6	33.1
Subcontracting, BA	1.3	0.2	0.2	0	0	0	0
Procurement, BA	2.1	0	0	0	0	0	0
Capital equipment, BA	0.2	0	0	0	0	0	0
Direct personnel, FTE	146	206	202	209	212	211	213
Nuclear Regulatory Commission							
Operating							
BO	23.7	25.2	20.1	19.7	20.1	20.6	21.1
BA	24.5	25.2	20.1	19.7	20.1	20.6	21.1
Subcontracting, BA	1.8	1.4	1.4	1.5	1.5	1.5	1.5
Procurement, BA	2.2	3.4	2.2	2.2	2.2	2.2	2.2
Direct personnel, FTE	217	210	175	160	160	160	160
Other non-DOE							
Operating							
BO	18.6	21.0	20.9	21.5	22.5	23.0	23.5
BA	18.6	21.0	20.9	21.5	22.5	23.0	23.5
Subcontracting, BA	0.6	*	*	*	*	*	*
Procurement, BA	1.7	0	0	0	0	0	0
Direct personnel, FTE	219	250	234	240	247	253	260
Isotopes production[g]							
Direct personnel, FTE[h]	42	43	46	46	46	46	46
Total, Laboratory operating							
Operating							
BO	277.5	335.1	362.4	388.4	380.8	385.1	391.6
BA	286.1	338.1	375.9	361.3	381.9	387.4	393.0
Subcontracting, BA	49.1	73.4	89.1	93.7	88.0	87.8	88.3
Procurement, BA	29.9	31.2	37.2	39.5	37.8	37.8	39.4
Capital equipment, BA	19.0	28.7	29.8	32.2	28.0	29.5	29.7
Direct personnel, FTE	2321	2520	2518	2554	2582	2607	2630
General-purpose automated data processing equipment, BA	0.4	1.2	10.9	1.0	1.0	1.0	1.0
General plant projects, BA	3.1	4.8	6.3	6.0	6.0	6.0	6.0
Proposed general-purpose facilities							
Energy Systems Research Laboratory	0	0	2.0	18.0	0	0	0
Other	0	0	12.5	31.6	26.3	19.4	17.3
Proposed programmatic facilities[i]	0	5.8	49.9	113.4	7.3	23.2	0

[a]Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. An asterisk indicates funding of less than $50,000. Because of rounding, the sum of the individual costs for a given year may not equal the total shown.

[g]Operating funds are included under DOE reimbursements, other non-DOE, and the Director of Energy Research.

[h]These figures exclude electromagnetic stable isotopes separation, which involves 24 FTEs listed under the Director of Energy Research.

[i]Proposed but not yet funded or budgeted (others are shown under the appropriate secretarial office).

Table B.3. Summary of resources – Assistant Secretary for Energy Technology[a]

	Fiscal year						
	'79	'80	'81	'82	'83	'84	'85
Coal Preparation and Analysis (AA 10 03)							
Operating							
BO[b]	0.4	0.7	0.9	1.2	1.5	1.5	1.5
BA[c]	0.4	0.7	1.0	1.3	1.5	1.5	1.5
Subcontracting, BA	0.2	0.1	0.1	0.4	0.7	0.7	0.7
Procurement, BA	0.1	*	0.1	0.1	0.3	0.3	0.3
Capital equipment, BA	0	0.2	1.4	1.2	0.5	0.3	0.2
Direct personnel, FTE[d]	3	7	8	8	8	8	8
Liquefaction Engineering Support (AA 20 03)							
Operating							
BO	1.9	2.2	3.0	3.6	4.5	5.7	6.0
BA	0.9	2.5	3.2	3.9	4.9	5.8	6.0
Subcontracting, BA	0.6	0.1	0.1	0.5	0.5	0.4	0.5
Procurement, BA	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Capital equipment, BA	0	0.2	0.3	0.3	0.4	0.5	0.5
Direct personnel, FTE	16	17	24	26	33	43	45
Low-Btu Gasification (AA 30 02)							
Operating							
BO	0	0.1	0.1				
BA	0	0.1	0.1				
Subcontracting, BA	0	0	0				
Procurement, BA	0	0	0				
Capital equipment, BA	0	0	0				
Direct personnel, FTE	0	1	1				
Special Projects and Support Studies (AA 30 03)							
Operating							
BO	0.7	0.5	0.5				
BA	0.4	0.5	0.5				
Subcontracting, BA	0.3	0.5	0.5				
Procurement, BA	*	*	*				
Capital equipment, BA	*	*	*				
Direct personnel, FTE	4	*	*				
Gasification Demonstration Plants (AA 30 04)							
Operating							
BO	2.0	1.5	2.5				
BA	1.4	1.8	2.5				
Subcontracting, BA	0.5	0.7	1.7				
Procurement, BA	0.1	0.1	0.1				
Capital equipment, BA	*	*	*				
Direct personnel, FTE	12	7	7				

[a]Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. An asterisk indicates funding of less than $50,000. Because of rounding, the sum of the individual costs for a given year may not equal the total shown.

[b]Budget outlay.

[c]Budget authorization.

[d]Full-time equivalent (FTE) person-years.

Table B.3[a] (continued)

	Fiscal year						
	'79	'80	'81	'82	'83	'84	'85
Total, Surface Coal Gasification (AA 30)							
Operating							
BO	2.7	2.1	3.1	3.1	3.1	3.1	3.1
BA	1.8	2.4	3.1	3.1	3.1	3.1	3.1
Subcontracting, BA	0.8	1.2	2.2	2.2	2.2	2.2	2.2
Procurement, BA	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Capital equipment, BA	*	*	*	*	*	*	*
Direct personnel, FTE	16	8	8	8	8	8	8
Open-Cycle Systems (AA 40 01)							
Operating							
BO	0	0	0				
BA	0.2	0	0				
Subcontracting, BA	0	0	0				
Procurement, BA	0	0	0				
Capital equipment, BA	0	0	0				
Direct personnel, FTE	0	0	0				
Support and Additional Programs (AA 40 03)							
Operating							
BO	0.1	0.1	0.1				
BA	0	0.1	0.1				
Subcontracting, BA	0	0	0				
Procurement, BA	0	0	0				
Capital equipment, BA	0	0	0				
Direct personnel, FTE	1	1	1				
Total, Advanced Power Systems (AA 40)							
Operating							
BO	0.1	0.1	0.1	0.1	0.1	0.1	0.1
BA	0.2	0.1	0.1	0.1	0.1	0.1	0.1
Subcontracting, BA	0	0	0	0	0	0	0
Procurement, BA	*	0	0	0	0	0	0
Capital equipment, BA	0	0	0	0	0	0	0
Direct personnel, FTE	1	1	1	1	1	1	1
Atmospheric Fluidized Beds (AA 50 01)							
Operating							
BO	0.3	2.5	2.5				
BA	0.7	2.5	2.2				
Subcontracting, BA	0	1.8	1.8				
Procurement, BA	0	0	0				
Capital equipment, BA	0.1	0.2	0.2				
Direct personnel, FTE	3	6	6				
Coal Combustion Support (AA 50 04)							
Operating							
BO	0	0.3	0.3				
BA	0	0.3	0.3				
Subcontracting, BA	0	*	*				
Procurement, BA	0	*	*				
Capital equipment, BA	0	*	*				
Direct personnel, FTE	0	3	3				

[a]Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. An asterisk indicates funding of less than $50,000. Because of rounding, the sum of the individual costs for a given year may not equal the total shown.

Table B.3[a] (continued)

	Fiscal year						
	'79	'80	'81	'82	'83	'84	'85
Combustion Demo Plants (AA 50 05)							
Operating							
BO	0	0.1	0.1				
BA	0	0.2	0.2				
Subcontracting, BA	0	0	0				
Procurement, BA	0	0	0				
Capital equipment, BA	*	*	*				
Direct personnel, FTE	0	1	1				
Total, Direct Combustion (AA 50)							
Operating							
BO	0.3	2.9	3.0	2.0	1.5	1.5	1.5
BA	0.7	3.0	2.7	1.8	1.5	1.5	1.5
Subcontracting, BA	0	1.8	1.8	0.8	0.3	0.3	0.3
Procurement, BA	0	*	*	*	*	*	*
Capital equipment, BA	0.1	0.2	0.2	0.1	0.1	0.1	0.1
Direct personnel, FTE	3	10	11	11	11	11	11
Processes (AA 60 01)							
Operating							
BO	0.2	0.7	0.8				
BA	0.2	0.7	0.8				
Subcontracting, BA	0	0	0				
Procurement, BA	0	0	0				
Capital equipment, BA	0	0.1	0.1				
Direct personnel, FTE	1	6	6				
Direct Utilization (AA 60 02)							
Operating							
BO	0	0.3	0.3				
BA	0	0.3	0.3				
Subcontracting, BA	0	0	0				
Procurement, BA	*	0	0				
Capital equipment, BA	0	*	*				
Direct personnel, FTE	0	2	2				
Materials and Components (AA 60 03)							
Operating							
BO	0.5	5.5	6.5				
BA	0.5	6.1	6.7				
Subcontracting, BA	0	4.5	5.5				
Procurement, BA	0.1	0.1	0.1				
Capital equipment, BA	0	0.5	0.6				
Direct personnel, FTE	5	8	8				
Program Development and Coordination (AA 60 04)							
Operating							
BO	0.6	2.1	3.1				
BA	1.3	2.4	3.4				
Subcontracting, BA	0.1	0.7	1.5				
Procurement, BA	0	0	0				
Capital equipment, BA	*	*	*				
Direct personnel, FTE	5	12	12				

[a]Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. An asterisk indicates funding of less than $50,000. Because of rounding, the sum of the individual costs for a given year may not equal the total shown.

Table B.3[a] (continued)

	Fiscal year						
	'79	'80	'81	'82	'83	'84	'85
Total, Advanced Research and Development (AA 60)							
Operating							
BO	1.3	8.6	10.6	12.2	12.2	12.2	12.2
BA	2.0	9.5	11.1	12.2	12.2	12.2	12.2
Subcontracting, BA	0.1	5.2	7.0	7.7	7.7	7.7	7.7
Procurement, BA	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Capital equipment, BA	*	0.6	0.7	0.7	0.8	0.8	0.8
Direct personnel, FTE	11	29	31	31	31	31	31
In Situ Coal Gasification – Supporting Research (AA 80 06)							
Operating							
BO	0.1	0.2	0.2	0.2	0.2	0.2	0.2
BA	0.1	0.2	0.2	0.2	0.2	0.2	0.2
Subcontracting, BA	0	0	0	0	0	0	0
Procurement, BA	0	0	0	0	0	0	0
Capital equipment, BA	*	*	*	*	*	*	*
Direct personnel, FTE	2	2	2	2	2	2	2
Enhanced Oil Recovery (AB 10)							
Operating							
BO	0.7	0.5	0.5	0.5	0.5	0.5	0.5
BA	0.7	0.5	0.5	0.5	0.5	0.5	0.5
Subcontracting, BA	0	0	0	0	0	0	0
Procurement, BA	0.1	*	*	0.1	0.1	0.1	0.1
Capital equipment, BA	0	0.1	0.1	0.1	0.1	0.1	0.1
Direct personnel, FTE	9	6	6	6	6	6	6
Improved Conversion Efficiency (C8 03 03)							
Operating							
BO	0.6	0.3	0.3	0.3	0.3	0.3	0.3
BA	2.5	0.3	0.3	0.3	0.3	0.3	0.3
Subcontracting, BA	0.1	0	0	0	0	0	0
Procurement, BA	*	*	*	*	*	*	*
Capital equipment, BA	0.1	*	*	*	*	*	*
Direct personnel, FTE	6	3	3	3	3	3	3
Total, Energy Technology (ET) – Fossil							
Operating							
BO	8.2	17.5	21.8	23.1	23.8	25.0	25.3
BA	6.1	19.1	22.2	23.4	24.2	25.1	25.3
Subcontracting, BA	1.8	8.3	11.1	11.4	11.3	11.2	11.3
Procurement, BA	0.5	0.2	0.3	0.4	0.6	0.6	0.6
Capital equipment, BA	0.2	1.3	2.6	2.5	1.9	1.7	1.7
Direct personnel, FTE	68	82	90	95	102	112	114
Environmental and Resource Assessment (AD 02 01)							
Operating							
BO	0.9	1.2	1.7	1.8	1.8	1.8	1.8
BA	0.8	1.3	1.9	1.8	1.8	1.8	1.8
Subcontracting, BA	0.4	0.5	0.9	0.9	0.9	0.9	0.9
Procurement, BA	*	*	*	*	*	*	*
Capital equipment, BA	*	*	0.1	0.1	0.1	0.1	0.1
Direct personnel, FTE	6	8	8	8	8	8	8

[a]Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. An asterisk indicates funding of less than $50,000. Because of rounding, the sum of the individual costs for a given year may not equal the total shown.

Table B.3[a] (continued)

	Fiscal year						
	'79	'80	'81	'82	'83	'84	'85
Solar Thermal Power (AD 03 01)							
Operating							
BO	0.7	1.4	1.9				
BA	0.6	1.5	1.9				
Subcontracting, BA	0.1	0.3	0.8				
Procurement, BA	*	*	*				
Capital equipment, BA	*	*	*				
Direct personnel, FTE	6	8	8				
Photovoltaic Energy Conversion (AD 03 02)							
Operating							
BO	0.1	0.5	0.7				
BA	0.2	0.5	0.7				
Subcontracting, BA	0	0	2				
Procurement, BA	*	*	*				
Capital equipment, BA	*	*	*				
Direct personnel, FTE	2	4	4				
Ocean Thermal Energy Conversion (AD 03 04)							
Operating							
BO	0.8	1.0	1.4				
BA	1.0	1.1	1.4				
Subcontracting, BA	0.4	0.5	0.6				
Procurement, BA	*	*	*				
Capital equipment, BA	*	*	*				
Direct personnel, FTE	3	5	5				
Total, Solar Electric Applications (AD 03)							
Operating							
BO	1.6	2.9	4.0	4.0	4.0	4.0	4.0
BA	1.8	3.0	4.0	4.0	4.0	4.0	4.0
Subcontracting, BA	0.5	0.9	1.7	1.9	1.9	1.9	1.9
Procurement, BA	*	*	*	0.1	0.1	0.1	0.1
Capital equipment, BA	*	0.1	0.1	0.1	0.1	0.1	0.1
Direct personnel, FTE	11	16	17	17	17	17	17
Fuels and Biomass (AJ 01)							
Operating							
BO	0.2	0.9	1.2	1.3	1.3	1.3	1.3
BA	0.2	1.1	1.3	1.3	1.3	1.3	1.3
Subcontracting, BA	*	0.1	0.3	0.5	0.5	0.5	0.5
Procurement, BA	*	0.1	0.1	0.1	0.1	0.1	0.1
Capital equipment, BA	0	*	0.1	0.1	0.1	0.1	0.1
Direct personnel, FTE	1	6	6	8	8	8	8
Total, ET – Solar							
Operating							
BO	2.7	5.0	6.9	7.2	7.2	7.2	7.2
BA	2.7	5.5	7.2	7.2	7.2	7.2	7.2
Subcontracting, BA	0.9	1.5	2.8	3.3	3.3	3.3	3.3
Procurement, BA	0	0.1	0.1	0.1	0.1	0.1	0.1
Capital equipment, BA	*	0.2	0.3	0.3	0.3	0.3	0.3
Direct personnel, FTE	18	30	31	33	34	33	33

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Table B.3[a] (continued)

	Fiscal year						
	'79	'80	'81	'82	'83	'84	'85
Geothermal Technology Development (AE 30)							
Operating							
BO	0.9	0.9	1.0	1.0	1.0	1.0	1.0
BA	0.8	0.9	1.0	1.0	1.0	1.0	1.0
Subcontracting, BA	0.2	0.2	0.2	0.3	0.3	0.3	0.3
Procurement, BA	*	*	*	*	*	*	*
Capital equipment, BA	*	*	*	*	*	*	*
Direct personnel, FTE	7	8	8	8	8	8	8
Tokamak Systems Experiments (AF 01 10)							
Operating							
BO	11.6	11.0	11.6	12.6	12.6	12.6	12.6
BA	8.9	11.4	10.4	12.6	12.6	12.6	12.6
Subcontracting, BA	0.4	0.3	0.1	0	0	0	0
Procurement, BA	1.5	2.6	3.2	6.5	5.6	5.0	5.0
Capital equipment, BA	1.8	2.5	1.3	1.2	0.3	0	0
Direct personnel, FTE	45	35	35	39	39	39	39
Magnetic Systems (AF 02 10)							
Operating							
BO	11.4	12.1	12.6				
BA	16.1	11.1	12.8				
Subcontracting, BA	7.1	8.2	6.0				
Procurement, BA	0.5	3.1	4.6				
Capital equipment, BA	1.9	4.5	1.3				
Direct personnel, FTE	20	22	23				
Plasma Engineering (AF 02 20)							
Operating							
BO	6.4	5.2	5.5				
BA	4.3	4.6	5.5				
Subcontracting, BA	1.0	3.1	3.1				
Procurement, BA	0.8	0.8	0.9				
Capital equipment, BA	0.7	1.4	0.3				
Direct personnel, FTE	22	27	29				
Fusion Reactor Materials (AF 02 30)							
Operating							
BO	3.0	3.5	3.7				
BA	2.3	3.6	3.9				
Subcontracting, BA	0	0	0				
Procurement, BA	0.1	0.1	0.1				
Capital equipment, BA	0.9	0.6	0.7				
Direct personnel, FTE	25	24	24				
Fusion Systems Engineering (AF 02 40)							
Operating							
BO	2.0	4.5	6.1				
BA	2.3	4.1	6.4				
Subcontracting, BA	0.6	3.0	3.9				
Procurement, BA	*	*	*				
Capital equipment, BA	*	0.1	*				
Direct personnel, FTE	8	14	17				

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Table B.3[a] (continued)

	Fiscal year						
	'79	'80	'81	'82	'83	'84	'85
Environment and Safety (AF 02 50)							
Operating							
BO	0.3	0.6	1.5				
BA	0.3	0.6	1.5				
Subcontracting, BA	0	0	0				
Procurement, BA	0	0	0				
Capital equipment, BA	*	*	*				
Direct personnel, FTE	3	1	1				
Total, Development and Technology (AF 02)							
Operating							
BO	23.1	25.9	29.4	36.1	32.2	33.4	35.0
BA	25.3	24.0	30.1	19.5	32.6	33.9	35.0
Subcontracting, BA	8.4	14.3	13.0	14.0	12.5	13.0	13.5
Procurement, BA	1.4	4.0	5.6	6.0	5.3	5.5	5.8
Capital equipment, BA	3.5	6.6	2.3	4.7	5.0	5.5	6.0
Direct personnel, FTE	78	88	94	94	94	94	94
Applied Plasma Physics – Advanced Fusion Concepts (AF 03 10)							
Operating							
BO	3.6	12.2	21.0				
BA	4.9	16.5	24.0				
Subcontracting, BA	0.5	9.8	20.5				
Procurement, BA	0.4	1.7	3.4				
Capital equipment, BA	0.3	0.5	0.7				
Direct personnel, FTE	13	20	23				
Fusion Plasma Theory (AF 03 20)							
Operating							
BO	2.3	3.0	3.4				
BA	1.6	3.1	3.6				
Subcontracting, BA	0.1	0.1	0.1				
Procurement, BA	*	*	*				
Capital equipment, BA	0	0	0				
Direct personnel, FTE	14	22	23				
Experimental Plasma Research (AF 03 30)							
Operating							
BO	0.9	1.0	1.2				
BA	0.6	1.0	1.2				
Subcontracting, BA	*	*	*				
Procurement, BA	0	*	0.1				
Capital equipment, BA	0.1	0.1	0.2				
Direct personnel, FTE	12	13	14				
National MFE Computer Network (AF 03 40)							
Operating							
BO	0.3	0.4	0.5				
BA	0.3	0.4	0.5				
Subcontracting, BA	0	0	0				
Procurement, BA	0.2	0.2	0.2				
Capital equipment, BA	0	0.4	0.2				
Direct personnel, FTE	0	2	2				

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Table B.3[a] (continued)

	Fiscal year						
	'79	'80	'81	'82	'83	'84	'85
Total, Applied Plasma Physics (AF 03)							
Operating							
BO	7.1	16.5	26.1	31.3	24.5	23.0	23.3
BA	7.4	21.0	29.3	19.4	24.0	23.1	23.3
Subcontracting, BA	0.6	12.9	20.6	20.1	16.1	15.1	15.1
Procurement, BA	0.5	1.9	3.7	0.3	0.3	0.3	0.3
Capital equipment, BA	0.4	0.9	1.1	0.2	0.2	0.2	0.2
Direct personnel, FTE	40	57	62	62	62	62	62
Total, ET – Fusion							
Operating							
BO	41.8	53.4	67.1	80.0	69.3	69.0	70.9
BA	41.6	56.4	69.8	51.5	69.2	69.6	70.9
Subcontracting, BA	9.4	27.5	33.7	34.1	28.6	28.1	28.6
Procurement, BA	3.4	8.5	12.5	12.8	11.2	10.8	11.1
Capital equipment, BA	5.7	10.0	4.7	6.1	5.5	5.7	6.2
Direct personnel, FTE	163	180	191	195	195	195	195
Sodium-Cooled Breeder (AG 10 20)							
Operating							
BO	11.9	12.9	13.9	14.0	14.0	14.0	14.0
BA	10.9	13.2	14.3	14.0	14.0	14.0	14.0
Subcontracting, BA	1.0	1.3	1.4	1.3	1.3	1.3	1.3
Procurement, BA	2.3	1.6	1.8	1.7	1.7	1.7	1.7
Capital equipment, BA	1.0	1.9	2.2	2.0	2.0	2.0	2.0
Direct personnel, FTE	105	116	115	120	120	120	120
Gas-Cooled Breeder Reactors (AG 10 30)							
Operating							
BO	4.6	5.5	6.6	6.0	6.0	5.5	5.2
BA	4.8	5.3	6.8	6.0	5.8	5.4	5.2
Subcontracting, BA	0.1	0	0	0	0	0	0
Procurement, BA	2.5	2.8	3.1	1.8	1.8	1.5	1.4
Capital equipment, BA	0.8	0.1	0.1	0.1	0.1	0.1	0.1
Direct personnel, FTE	24	26	40	40	40	38	35
Light-Water Reactor (AG 20 10)							
Operating							
BO	0.2	0.7	0.7	0.4	0.2	0.2	0.2
BA	0.2	0.7	0.6	0.4	0.2	0.2	0.2
Subcontracting, BA	0	0.3	0.2	0.2	0	0	0
Procurement, BA	0.2	0.1	0.1	0	0	0	0
Capital equipment, BA	0	0.1	0.1	0.1	0.1	0.1	0.1
Direct personnel, FTE	0	2	3	2	2	2	2
Gas-Cooled Thermal Reactors (AG 20 30)							
Operating							
BO	4.8	4.0	4.5	5.0	5.0	5.0	5.0
BA	5.8	4.2	5.2	5.0	5.0	5.0	5.0
Subcontracting, BA	0.4	1.1	2.1	2.4	2.4	2.4	2.4
Procurement, BA	0.9	0.6	0.9	1.0	1.0	1.0	1.0
Capital equipment, BA	1.0	0.5	0.5	0.5	0.5	0.5	0.5
Direct personnel, FTE	42	31	21	23	25	25	26

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Table B.3[a] (continued)

	Fiscal year						
	'79	'80	'81	'82	'83	'84	'85
Fuel Cycle Research and Development (AG 20 40)							
Operating							
BO	33.0	33.6	30.0	37.5	37.5	37.5	37.5
BA	31.3	23.5	36.2	37.5	37.5	37.5	37.5
Subcontracting, BA	13.6	13.0	7.4	10.5	10.5	10.4	10.2
Procurement, BA	7.0	4.6	5.7	8.2	8.2	8.2	8.2
Capital equipment, BA	1.7	2.5	4.4	4.5	3.9	3.7	3.7
Direct personnel, FTE	189	175	187	189	189	194	204
Fuel Cycle Research and Development[e] (AG 20 40)							
Operating							
BO	4.3	0.5	0.5	0.5	0.5	0.5	0.5
BA	4.5	0.5	0.5	0.5	0.5	0.5	0.5
Subcontracting, BA	0.1	0	0	0	0	0	0
Procurement, BA	0.8	0	0	0	0	0	0
Capital equipment, BA	0.2	0	0	0	0	0	0
Direct personnel, FTE	57	5	5	5	5	5	5
Facility Management and Operations – Power Development (Nuclear Standards) (AG 20 60)							
Operating							
BO	0.7	0.9	1.0	1.0	1.0	1.0	1.0
BA	0.7	0.9	1.0	1.0	1.0	1.0	1.0
Subcontracting, BA	0	0	0	0	0	0	0
Procurement, BA	0	0.1	0.1	0.1	0.1	0.1	0.1
Capital equipment, BA	0	0	0	0	0	0	0
Direct personnel, FTE	11	12	11	11	11	11	11
Commercial and Defense Waste Management (AG 30 and JM 05)[f]							
Operating							
BO	10.7	16.2	20.3	22.4	23.8	25.9	27.8
BA	11.6	18.2	21.7	23.1	24.3	26.6	28.5
Subcontracting, BA	1.6	0.2	0.1	0.1	0	0	0
Procurement, BA	2.2	4.5	4.3	5.5	7.0	8.9	10.3
Capital equipment, BA	0.6	2.2	3.2	2.9	2.3	1.8	1.3
Direct personnel, FTE	87	150	160	168	168	170	175
Space and Terrestrial Systems (AG 40 20)							
Operating							
BO	1.7	1.7	1.7	1.3	1.3	1.3	1.3
BA	2.1	1.7	1.7	1.2	1.3	1.3	1.3
Subcontracting, BA	0	0	0	0	0	0	0
Procurement, BA	0.2	0.3	0.2	0.1	0.2	0.2	0.2
Capital equipment, BA	0.1	0.1	0.2	0.1	0.1	0.1	0.1
Direct personnel, FTE	19	16	16	13	12	12	12

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[e]Funding for this part of the fuel cycle work comes through the Richland Operations Office (Battelle Pacific Northwest Laboratories in FY 1979 and Hanford Engineering Development Laboratory in FY 1980) and will actually be provided as DOE reimbursements, as indicated under DOE reimbursements on p. 139. Care should be taken to avoid double accounting.

[f]After FY 1979, most of this funding will actually be provided as DOE reimbursements, as indicated under DOE reimbursements on p. 139. Care should be taken to avoid double accounting.

Table B.3[a] (continued)

	Fiscal year						
	'79	'80	'81	'82	'83	'84	'85
Advanced Systems Evaluations (AG 40 30)							
Operating							
BO	5.2	2.8	2.7	3.0	3.0	3.5	3.5
BA	4.7	2.8	2.8	3.0	3.2	3.5	3.5
Subcontracting, BA	2.6	0.7	0.8	1.1	1.2	1.6	1.6
Procurement, BA	0.5	0.1	0.1	0.1	0.1	0.1	0.1
Capital equipment, BA	0	0.1	0.1	0	0	0	0
Direct personnel, FTE	31	25	20	22	21	22	22
Total, ET – Fission (excluding DOE reimbursements)							
Operating							
BO	69.9	69.1	67.9	75.1	74.3	73.9	73.5
BA	69.1	61.3	76.8	75.7	74.8	74.5	74.2
Subcontracting, BA	19.3	8.6	12.0	15.6	15.4	15.7	15.5
Procurement, BA	15.8	14.7	16.3	18.5	20.1	21.7	23.0
Capital equipment, BA	5.2	7.5	10.8	10.2	9.0	8.4	7.7
Direct personnel, FTE	492	459	474	480	475	476	481
Fuels and Biomass (AJ 01)[g]							
Power Supply Integration (C1 07 01)							
Operating							
BO	3.4	6.9	8.9				
BA	3.9	6.9	8.3				
Subcontracting, BA	3.0	6.2	8.3				
Procurement, BA	0	0	0				
Capital equipment, BA	0.1	0.1	0.1				
Direct personnel, FTE	8	8	8				
Power Delivery (C1 07 02)							
Operating							
BO	0.4	0.6	0.7				
BA	0.5	0.6	0.7				
Subcontracting, BA	0.1	0.1	0.1				
Procurement, BA	*	*	*				
Capital equipment, BA	0.1	0.1	0.1				
Direct personnel, FTE	4	5	5				
Total, Electric Energy Systems (C1 07)							
Operating							
BO	3.9	7.5	9.6	9.6	9.6	9.6	9.6
BA	4.4	7.5	9.0	9.6	9.6	9.6	9.6
Subcontracting, BA	3.1	6.3	8.4	8.4	8.4	8.4	8.4
Procurement, BA	0	*	*	*	*	*	*
Capital equipment, BA	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Direct personnel, FTE	12	13	13	13	13	13	13
Battery Storage (C8 03 01)							
Operating							
BO	0	0.1	0.2				
BA	0.1	0.1	0.2				
Subcontracting, BA	0	0	0				
Procurement, BA	0	0	0				
Capital equipment, BA	*	*	*				
Direct personnel, FTE	1	1	1				

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[g]This activity is given as an entry for Energy Technology – Solar on p. 120.

Table B.3[a] (continued)

	Fiscal year						
	'79	'80	'81	'82	'83	'84	'85
Chemical, Mechanical, and Other Storage (C8 03 02)							
Operating							
BO	1.9	2.2	2.3				
BA	2.1	2.2	2.3				
Subcontracting, BA	1.3	1.7	1.8				
Procurement, BA	0	0	0				
Capital equipment, BA	0.1	0	0				
Direct personnel, FTE	7	7	8				
Improved Conversion Efficiency (C8 03 03)[h]							
Multisector, Technology Development (C8 03, excluding C8 03 03)							
Operating							
BO	1.9	2.3	2.5	2.5	2.5	2.5	2.5
BA	2.2	2.3	2.5	2.5	2.5	2.5	2.5
Subcontracting, BA	1.3	1.7	1.8	1.8	1.8	1.8	1.8
Procurement, BA	0	0	0	0	0	0	0
Capital equipment, BA	0.1	*	*	*	*	*	*
Direct personnel, FTE	8	8	9	9	9	9	9
Total, ET – Conservation (C1 and C8, excluding C8 03 03)							
Operating							
BO	5.7	9.1	12.1	12.1	12.1	12.1	12.1
BA	9.1	9.8	11.6	12.1	12.1	12.1	12.1
Subcontracting, BA	4.4	8.0	10.2	10.2	10.2	10.2	10.2
Procurement, BA	*	*	*	*	*	*	*
Capital equipment, BA	0.3	0.2	0.2	0.2	0.2	0.2	0.2
Direct personnel, FTE	20	21	22	22	22	22	22

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[h]This subactivity is given as an entry for Energy Technology – Fossil on p. 119.

Table B.4. Summary of resources – Director of Energy Research[a]

	Fiscal year						
	'79	'80	'81	'82	'83	'84	'85
Nuclear Sciences (AK 01 01)							
Operating							
BO[b]	11.2	12.3	13.5				
BA[c]	11.8	12.4	13.6				
Subcontracting, BA	0	0.1	0.2				
Procurement, BA	0.5	0	0				
Capital equipment, BA	0.3	0.5	0.6				
Direct personnel, FTE[d]	149	163	162				
Materials Sciences (AK 01 02)							
Operating							
BO	14.8	16.1	17.9				
BA	14.6	16.8	18.6				
Subcontracting, BA	0.1	0.2	0.2				
Procurement, BA	0.5	0	0				
Capital equipment, BA	1.6	1.9	2.3				
Direct personnel, FTE	180	172	174				
Chemical Sciences (AK 01 03)							
Operating							
BO	6.8	7.8	8.9				
BA	6.8	8.3	9.2				
Subcontracting, BA	0	0.1	0.1				
Procurement, BA	0	0	0				
Capital equipment, BA	0.6	0.9	1.0				
Direct personnel, FTE	90	99	102				
Engineering, Mathematical, and Geosciences (AK 01 04)							
Operating							
BO	0.7	1.1	1.3				
BA	0.8	1.1	1.3				
Subcontracting, BA	0	0	0				
Procurement, BA	0	0	0				
Capital equipment, BA	0	0.1	0.3				
Direct personnel, FTE	3	5	6				
Advanced Energy Projects (AK 01 05)							
Operating							
BO	0.4	0.5	0.5				
BA	0.3	0.5	0.5				
Subcontracting, BA	0	0	0				
Procurement, BA	0	0	0				
Capital equipment, BA	0	0	0				
Direct personnel, FTE	4	5	5				
Biological Energy Conversion and Conservation (AK 01 06)							
Operating							
BO	0	0.2	0.3				
BA	0	0.2	0.3				
Subcontracting, BA	0	0	0				
Procurement, BA	0	0	0				
Capital equipment, BA	0	0	0				
Direct personnel, FTE	0	2.0	2.0				

[a]Funding for FY 1979 through 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. An asterisk indicates funding of less than $50,000. Because of rounding, the sum of the individual costs for a given year may not equal the total shown.

[b]Budget outlay.

[c]Budget authorization.

[d]Full-time equivalent (FTE) person-years.

Table B.4[a] (continued)

	Fiscal year						
	'79	'80	'81	'82	'83	'84	'85
Total, Basic Energy Sciences (AK 01)							
Operating							
BO	34.0	38.0	42.4	43.1	44.1	45.3	46.4
BA	34.4	39.3	43.5	43.6	44.5	45.7	46.8
Subcontracting, BA	0.1	0.4	0.5	0.5	0.5	0.6	0.6
Procurement, BA	1.0	0	0	0	0	0	0
Capital equipment, BA	2.5	3.4	4.2	4.7	4.9	5.5	5.5
Direct personnel, FTE	426	446	451	457	462	467	472
High-Energy Physics (HK 02)							
Operating							
BO	0.4	0.5	0.5	0.5	0.5	0.5	0.5
BA	0.4	0.5	0.5	0.5	0.5	0.5	0.5
Subcontracting, BA	0	0	0	0	0	0	0
Procurement, BA	0	0	0	0	0	0	0
Capital equipment, BA	0	0	0	0	0	0	0
Direct personnel, FTE	4	6	5	5	5	5	5
Medium-Energy Nuclear Physics (HK 03 01)							
Operating							
BO	0.1	0.1	0.1				
BA	0.1	0.1	0.1				
Subcontracting, BA	0	0	0				
Procurement, BA	0	0	0				
Capital equipment, BA	0	0	0				
Direct personnel, FTE	1	1	1				
Heavy-Ion Nuclear Physics (HK 03 02)							
Operating							
BO	5.0	5.8	6.5				
BA	5.0	6.1	6.7				
Subcontracting, BA	0	0.2	0.3				
Procurement, BA	0.2	0	0				
Capital equipment, BA	0.8	1.2	1.6				
Direct personnel, FTE	60	68	69				
Nuclear Theory (HK 03 03)							
Operating							
BO	0.5	0.6	0.7				
BA	0.5	0.6	0.7				
Subcontracting, BA	0	0	0				
Procurement, BA	0	0	0				
Capital equipment, BA	0	0	0				
Direct personnel, FTE	6	6	6				
Total, Nuclear Physics (HK 03)							
Operating							
BO	5.6	6.5	7.3	7.5	7.7	7.9	8.2
BA	5.6	6.8	7.5	7.6	7.8	8.0	8.4
Subcontracting, BA	0	0.2	0.3	0.3	0.4	0.4	0.5
Procurement, BA	0.2	0	0	0	0	0	0
Capital equipment, BA	0.8	1.2	1.6	1.7	1.5	1.2	1.1
Direct personnel, FTE	67	75	76	77	78	79	80

[a]Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. An asterisk indicates funding of less than $50,000. Because of rounding, the sum of the individual costs for a given year may not equal the total shown.

Table B.5. Summary of resources – Assistant Secretary for the Environment[a]

	Fiscal year						
	'79	'80	'81	'82	'83	'84	'85
Overview and Assessment (GK 01 01)							
Operating							
BO[b]	3.8	4.8	5.1	5.3	5.5	5.6	5.8
BA[c]	3.9	4.7	5.2	5.3	5.5	5.6	5.8
Subcontracting, BA	0.4	0.3	0.3	0.3	0.3	0.3	0.3
Procurement, BA	0.2	0.3	0	0	0	0	0
Capital equipment,[d] BA							
Direct personnel, FTE[e]	40	47	48	49	50	50	50
Biomedical and Environmental Research (GK 01 02)							
Operating							
BO	17.1	18.8	20.0	20.6	21.2	21.8	22.5
BA	17.0	19.2	20.4	20.6	21.2	21.8	22.5
Subcontracting, BA	0.9	1.2	1.1	1.1	1.1	1.1	1.1
Procurement, BA	0.7	0.8	1.0	1.0	1.0	1.0	1.0
Capital equipment,[d] BA							
Direct personnel, FTE	196	221	225	229	234	241	247
Total, Environmental Research and Development (GK 01)							
Operating							
BO	20.9	23.6	25.1	25.9	26.7	27.4	28.3
BA	20.9	23.9	25.6	25.9	26.7	27.4	28.3
Subcontracting, BA	1.3	1.5	1.4	1.4	1.4	1.4	1.4
Procurement, BA	0.9	1.1	1.0	1.0	1.0	1.0	1.0
Capital equipment, BA	1.6	2.3	1.7	1.9	2.0	2.0	2.0
Direct personnel, FTE	236	268	273	278	284	291	297
Life Sciences Research and Biomedical Applications (HK 01)							
Operating							
BO	6.3	6.7	7.0	7.2	7.4	7.6	7.9
BA	5.2	6.8	7.1	7.3	7.4	7.7	7.9
Subcontracting, BA	0.1	0.2	0.2	0.2	0.2	0.2	0.2
Procurement, BA	0.3	0.4	0.5	0.5	0.5	0.5	0.5
Capital equipment, BA	0.2	0.4	0.4	0.4	0.4	0.4	0.4
Direct personnel, FTE	73	77	77	78	79	79	80
Decontamination and Decommissioning (AG 70)							
Operating							
BO	2.4	3.2	3.6	3.7	3.8	3.9	4.0
BA	2.6	3.5	3.8	3.7	3.8	3.9	4.0
Subcontracting, BA	0.4	0.5	0.5	0.5	0.5	0.5	0.5
Procurement, BA	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Capital equipment, BA	*	0	0	0	0	0	0
Direct personnel, FTE	25	28	29	30	30	30	30

[a]Funding for FY 1979 through FT 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. An asterisk indicates funding of less than $50,000. Because of rounding, the sum of the individual costs for a given year may not equal the total shown.

[b]Budget outlay.

[c]Budget authorization.

[d]See the capital equipment total for GK 01.

[e]Full-time equivalent (FTE) person-years.

Table B.6. Summary of resources – Assistant Secretary for Conservation and Solar Applications[a]

	Fiscal year						
	'79	'80	'81	'82	'83	'84	'85
Residential and Commercial Buildings (C3 01 01)							
Operating							
BO[b]	1.4	1.7	1.7				
BA[c]	1.6	1.6	1.9				
Subcontracting, BA	0.6	0.8	0.8				
Procurement, BA	0	0	0				
Capital equipment, BA	0.1	0.1	*				
Direct personnel, FTE[d]	10	11	11				
Performance Standards (C3 01 02)							
Operating							
BO	1.0	1.5	1.6				
BA	1.4	1.6	1.7				
Subcontracting, BA	1.0	1.1	1.2				
Procurement, BA	0	0	0				
Capital equipment, BA	0.2	0.3	0.1				
Direct personnel, FTE	4	5	5				
Community Systems (C3 01 03)							
Operating							
BO	0.2	2.9	1.7				
BA	0.2	3.2	1.7				
Subcontracting, BA	0.2	2.2	1.0				
Procurement, BA	0	0	0				
Capital equipment, BA	0	0.1	*				
Direct personnel, FTE	0	9	9				
Consumer Products and Technology (C3 01 04)							
Operating							
BO	2.4	7.8	8.5				
BA	8.1	8.4	8.2				
Subcontracting, BA	1.8	6.8	7.5				
Procurement, BA	0	0	0				
Capital equipment, BA	0.1	0.1	0.1				
Direct personnel, FTE	9	12	12				
Technology Transfer, Economic Analysis, and Consumer Motivation (C3 01 05)							
Operating							
BO	0.2	0.5	0.6				
BA	0.2	0.5	0.6				
Subcontracting, BA	0	0	0				
Procurement, BA	0	0	0				
Capital equipment, BA	*	*	*				
Direct personnel, FTE	0	7	7				

[a]Funding for FY 1979 through 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. An asterisk indicates funding of less than $50,000. Because of rounding, the sum of the individual costs for a given year may not equal the total shown.

[b]Budget outlay.

[c]Budget authorization.

[d]Full-time equivalent (FTE) person-years.

Table B.6[a] (continued)

	Fiscal year						
	'79	'80	'81	'82	'83	'84	'85
Urban Waste Technology (C3 01 06)							
Operating							
BO	0.3	0.3	0.2				
BA	0.3	0.3	0.2				
Subcontracting, BA	0	0.1	0				
Procurement, BA	0	0	0				
Capital equipment, BA	*	*	*				
Direct personnel, FTE	3	3	3				
Total, Buildings and Community Systems (C3 01)							
Operating							
BO	5.4	14.7	14.2	14.2	14.2	14.2	14.2
BA	11.8	15.6	14.2	14.2	14.2	14.2	14.2
Subcontracting, BA	3.6	11.1	10.5	10.4	10.4	10.4	10.4
Procurement, BA	0	0	0	0	0	0	0
Capital equipment, BA	0.4	0.5	0.2	0.2	0.2	0.2	0.2
Direct personnel, FTE	26	46	46	47	47	47	47
Waste Energy Recovery and Utilization (C4 10 01)							
Operating							
BO	0.1	0.6	0.6	0.6	0.6	0.6	0.6
BA	0.2	0.6	0.6	0.6	0.6	0.6	0.6
Subcontracting, BA	0	0	0	0	0	0	0
Procurement, BA	0	*	0	0	0	0	0
Capital equipment, BA	0	0.1	0.1	0.1	0.1	0.1	0.1
Direct personnel, FTE	1	4	5	5	5	5	5
High-Temperature Processes (C4 20 01)							
Operating							
BO	0.4	0.2	0.2	0.2	0.2	0.2	0.2
BA	0.3	0.2	0.2	0.2	0.2	0.2	0.2
Subcontracting, BA	0.2	0	0	0	0	0	0
Procurement, BA	*	0	0	0	0	0	0
Capital equipment, BA	0	0	0	0	0	0	0
Direct personnel, FTE	2	2	2	2	2	2	2
Technology Dissemination (C4 30 04)							
Operating							
BO	0.1	0	0	0	0	0	0
BA	0.1	0	0	0	0	0	0
Subcontracting, BA	0.1	0	0	0	0	0	0
Procurement, BA	0.1	0	0	0	0	0	0
Capital equipment, BA	0	0	0	0	0	0	0
Direct personnel, FTE	0	0	0	0	0	0	0
Pipeline Systems (C5 02 01)							
Operating							
BO	0	0.2	0.2	0.2	0.2	0.2	0.2
BA	0	0.2	0.2	0.2	0.2	0.2	0.2
Subcontracting, BA	0	*	0.1	0.1	0.1	0.1	0.1
Procurement, BA	0	*	*	*	*	*	*
Capital equipment, BA	0	0.1	0.1	0.1	0.1	0.1	0
Direct personnel, FTE	0	1	1	1	1	1	1

[a]Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. An asterisk indicates funding of less than $50,000. Because of rounding, the sum of the individual costs for a given year may not equal the total shown.

Table B.6[a] (continued)

	Fiscal year						
	'79	'80	'81	'82	'83	'84	'85
Total, Non-Highway Transport Systems (C5 02)							
Operating							
BO	*	0.2	0.2	0.2	0.2	0.2	0.2
BA	0	0.2	0.2	0.2	0.2	0.2	0.2
Subcontracting, BA	0	*	0.1	0.1	0.1	0.1	0.1
Procurement, BA	0	*	*	*	*	*	*
Capital equipment, BA	0	0.1	0.1	0.1	0.1	0.1	0
Direct personnel, FTE	0	1	1	1	1	1	1
New Concepts (C5 03 02)							
Operating							
BO	0.1	0	0				
BA	*	0	0				
Subcontracting, BA	0	0	0				
Procurement, BA	0	0	0				
Capital equipment, BA	0	0	0				
Direct personnel, FTE	1	0	0				
Data Analysis (C5 03 03)							
Operating							
BO	0.6	0.5	0.5				
BA	0.6	0.5	0.5				
Subcontracting, BA	0.2	0.2	0.2				
Procurement, BA	0	0	0				
Capital equipment, BA	0	0	0				
Direct personnel, FTE	4	3	3				
Total, Technology Evaluation and Support (C5 03)							
Operating							
BO	0.7	0.5	0.5	0.5	0.5	0.5	0.5
BA	0.6	0.5	0.5	0.5	0.5	0.5	0.5
Subcontracting, BA	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Procurement, BA	0	0	0	0	0	0	0
Capital equipment, BA	0	0	0	0	0	0	0
Direct personnel, FTE	4	3	3	3	3	3	3
Demonstrations (C5 06 01)							
Operating							
BO	0	0	0	0	0	0	0
BA	0.1	0	0	0	0	0	0
Subcontracting, BA	0	0	0	0	0	0	0
Procurement, BA	0.1	0	0	0	0	0	0
Capital equipment, BA	0	0	0	0	0	0	0
Direct personnel, FTE	0	0	0	0	0	0	0
Total, Conservation and Solar Applications (CS) – Conservation (C3, C4, and C5)							
Operating							
BO	7.2	16.2	15.7	15.7	15.7	15.7	15.7
BA	13.9	17.1	15.7	15.7	15.7	15.7	15.7
Subcontracting, BA	4.0	11.3	10.8	10.7	10.7	10.7	10.7
Procurement, BA	0.1	*	*	*	*	*	*
Capital equipment, BA	0.4	0.6	0.3	0.3	0.3	0.3	0.3
Direct personnel, FTE	40	56	57	58	58	58	58

[a]Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. An asterisk indicates funding of less than $50,000. Because of rounding, the sum of the individual costs for a given year may not equal the total shown.

Table B.6[a] (continued)

	Fiscal year						
	'79	'80	'81	'82	'83	'84	'85
Demonstration (BD 01 01)							
Operating							
BO	0.4	0.5	0.5	0.5	0.5	0.5	0.5
BA	0.2	0.5	0.5	0.5	0.5	0.5	0.5
Subcontracting, BA	0.2	0.3	0.3	0.3	0.3	0.3	0.3
Procurement, BA	0	0	0	0	0	0	0
Capital equipment, BA	0	0	0	0	0	0	0
Direct personnel, FTE	4	3	3	3	3	3	3
Systems Development (BD 01 02)							
Operating							
BO	*	0.2	0.2	0.2	0.2	0.2	0.2
BA	0.1	0.2	0.2	0.2	0.2	0.2	0.2
Subcontracting, BA	0	0	*	*	*	*	*
Procurement, BA	0	0	0	0	0	0	0
Capital equipment, BA	0	0	0	0	0	0	0
Direct personnel, FTE	1	2	2	2	2	2	2
Total, Solar Applications (BD 01)							
Operating							
BO	0.6	0.6	0.7	0.7	0.7	0.7	0.7
BA	0.3	0.6	0.7	0.7	0.7	0.7	0.7
Subcontracting, BA	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Procurement, BA	0	0	0	0	0	0	0
Capital equipment, BA	0	0	0	0	0	0	0
Direct personnel, FTE	4	4	4	4	4	4	4
Commercialization Planning (BD 02 01)							
Operating							
BO	0.1	0.1	0.1	0.1	0.1	0.1	0.1
BA	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Subcontracting, BA	0	0	*	*	*	*	*
Procurement, BA	0	0	0	0	0	0	0
Capital equipment, BA	0	0	0	0	0	0	0
Direct personnel, FTE	0	1	1	1	1	1	1
Total, CS – Solar (BD)							
Operating							
BO	0.7	0.7	0.8	0.8	0.8	0.8	0.8
BA	0.6	0.7	0.8	0.8	0.8	0.8	0.8
Subcontracting, BA	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Procurement, BA	0	0	0	0	0	0	0
Capital equipment, BA	0	0	0	0	0	0	0
Direct personnel, FTE	4	5	5	5	5	5	5

[a]Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. An asterisk indicates funding of less than $50,000. Because of rounding, the sum of the individual costs for a given year may not equal the total shown.

DOE Headquarters feedback to Table B.6[a]

	Fiscal year						
	'79	'80	'81	'82	'83	'84	'85
Residential and Commercial Buildings (C3 01 01)							
Operating							
BO[b]	1.5	2.1					
BA[c]	1.6	2.0					
Subcontracting, BA	0.8	0.9					
Procurement, BA	0	0					
Capital equipment, BA	0.1	0.1					
Direct personnel, FTE[d]	9	11					
Performance Standards (C3 01 02)							
Operating							
BO	1.1	2.0					
BA	1.2	2.0					
Subcontracting, BA	0.8	1.1					
Procurement, BA	0	0					
Capital equipment, BA	0.2	0.3					
Direct personnel, FTE	5	5					
Residential Conservation Service (C3 01 03)							
Operating							
BO	1.8	2.9					
BA	1.8	2.9					
Subcontracting, BA	1.4	2.2					
Procurement, BA	0	0					
Capital equipment, BA	0	0					
Direct personnel, FTE	5	9					
Consumer Products and Technology (C3 01 04)							
Operating							
BO	7.2	7.8					
BA	7.7	8.8					
Subcontracting, BA	4.9	6.8					
Procurement, BA	0	0					
Capital equipment, BA	0.1	0.1					
Direct personnel, FTE	12	12					
Technology Transfer, Economic Analysis, and Consumer Motivation (C3 01 05)							
Operating							
BO	0.4	.25					
BA	0.2	.25					
Subcontracting, BA	0.1	0					
Procurement, BA	0	0					
Capital equipment, BA	*	*					
Direct personnel, FTE	4	2					

[a] *Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. An asterisk indicates funding of less than $50,000. Because of rounding, the sum of the individual costs for a given year may not equal the total shown.*

[b] *Budget outlay.*

[c] *Budget authorization.*

[d] *Full-time equivalent (FTE) person-years.*

Table B.7. Summary of resources – Assistant Secretary for Defense Programs[a]

	Fiscal year						
	'79	'80	'81	'82	'83	'84	'85
Special (Nuclear) Materials Production (JM 03)							
Operating							
BO[b]	2.4	4.3	5.5	6.0	4.0	2.5	2.0
BA[c]	2.4	5.8	5.1	5.8	4.0	3.0	2.3
Subcontracting, BA	0	0	0	0	0	0	0
Procurement, BA	0.6	2.1	3.5	3.2	1.5	0.1	0.1
Capital equipment, BA	0	0.1	0.3	0	0	0	0
Direct personnel, FTE[d]	18	23	25	25	25	24	18
Nuclear Materials Security and Safeguards (JM 04)							
Operating							
BO	0.2	0.2	0.2	0.2	0.2	0.2	0.2
BA	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Subcontracting, BA	0	0	0	0	0	0	0
Procurement, BA	0	0	0	0	0	0	0
Capital equipment, BA	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Direct personnel, FTE	2	2	2	2	2	2	2

[a]Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. Because of rounding, the sum of the individual costs for a given year may not equal the total shown. Subactivity JM 05 is listed with other waste programs under the summary of resources for the Assistant Secretary for Energy Technology.

[b]Budget outlay.

[c]Budget authorization.

[d]Full-time equivalent (FTE) person-years.

Table B.8. Summary of resources – Assistant Secretary for Resource Applications[a]

	Fiscal year						
	'79	'80	'81	'82	'83	'84	'85
Uranium Resource Assessment (BG 20)							
Operating							
BO[b]	1.0	1.0	0.9	1.2	1.3	1.3	1.3
BA[c]	1.0	1.1	0.9	1.3	1.3	1.3	1.3
Subcontracting, BA	0.1	0	0	0	0	0	0
Procurement, BA	0.7	0.3	0.4	0.4	0.3	0.4	0.4
Capital equipment, BA	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Direct personnel, FTE[d]	4	7	8	10	12	11	11
Small Hydroelectric Development (BH 01)							
Operating							
BO	0.3	0.5	0.7	1.0	1.2	1.2	1.2
BA	0.4	0.5	0.7	1.0	1.0	1.0	1.0
Subcontracting, BA	0.1	0.2	0.2	0.4	0.4	0.4	0.4
Procurement, BA	0	0	0	0	0	0	0
Capital equipment, BA	0	0	0	0	0	0	0
Direct personnel, FTE	4	4	6	7	7	7	7
Federal Leasing (BK 02 01)							
Operating							
BO	0	0.2	0.2	0.2	0.2	0.2	0.2
BA	0.1	0.2	0.2	0.2	0.2	0.2	0.2
Subcontracting, BA	0	0.1	0	0	0	0	0
Procurement, BA	0	0	0	0	0	0	0
Capital equipment, BA	0	0	0	0	0	0	0
Direct personnel, FTE	0	1	1	1	1	1	1

[a]Funding for FY 1979 through 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. Because of rounding, the sum of the individual costs for a given year may not equal the total shown.

[b]Budget outlay.

[c]Budget authorization.

[d]Full-time equivalent (FTE) person-years.

DOE Headquarters feedback to Table B.8[a]

	Fiscal Year						
	'79	*'80*	*'81*	*'82*	*'83*	*'84*	*'85*
Uranium Resource Assessment (BG 20)							
Operating							
BO[b]	*0.8*	*.5*	*.5*	*	*	*	*
BA[c]	*1.1*	*.5*	*.5*	*	*	*	*
Subcontracting, BA	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Procurement, BA	*0.5*	*	*	*	*	*	*
Capital equipment, BA	*0.1*	*	*	*	*	*	*
Direct personnel, FTE[d]	*5*	*7*	*8*	*10*	*12*	*11*	*11*

[a]Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. Because of rounding, the sum of the individual costs for a given year may not equal the total shown.

[b]Budget outlay.

[c]Budget authorization.

[d]Full-time equivalent (FTE) person-years.

**Figures not available at this time.*

Table B.9. Summary of resources – Other DOE Offices[a]

	Fiscal year						
	'79	'80	'81	'82	'83	'84	'85
Energy Analysis Forecasting (FK 01 01)							
Operating							
BO[b]	0.5	0.5	0.5	0.4	0.4	0.4	0.4
BA[c]	0.3	0.5	0.5	0.4	0.4	0.4	0.4
Subcontracting, BA	0.3	0.2	0.1	*	*	*	*
Procurement, BA	*	*	*	*	*	*	*
Capital equipment, BA	0	0	0	0	0	0	0
Direct personnel, FTE[d]	1	5	5	5	5	5	5
Consumption Data Base (FK 02 08)							
Operating							
BO	0.1	0.1	0.1	0.1	0.1	0.1	0.1
BA	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Subcontracting, BA	*	*	*	*	*	*	*
Procurement, BA	0	0	0	0	0	0	0
Capital equipment, BA	0	0	0	0	0	0	0
Direct personnel, FTE	1	2	2	2	2	2	2
Data Validation Program (FK 03 01)							
Operating							
BO	3.0	4.6	5.4	5.5	5.5	5.5	5.5
BA	2.7	4.9	5.4	5.5	5.5	5.5	5.5
Subcontracting, BA	2.2	2.6	2.8	2.8	2.8	2.8	2.8
Procurement, BA	0	0	0	0	0	0	0
Capital equipment, BA	*	0.1	0.1	0.1	0.1	0.1	0.1
Direct personnel, FTE	8	11	13	15	15	15	15
Total, Energy Information Administration							
Operating							
BO	3.6	5.2	6.0	6.0	6.0	6.0	6.0
BA	3.1	5.5	6.0	6.0	6.0	6.0	6.0
Subcontracting, BA	2.5	2.7	2.9	2.8	2.8	2.8	2.8
Procurement, BA	*	*	*	*	*	*	*
Capital equipment, BA	*	0.1	0.1	0.1	0.1	0.1	0.1
Direct personnel, FTE	10	17	19	22	22	22	22
Fuels Regulation (DK 01)							
Operating							
BO	0	0	0	0	0	0	0
BA	0.1	0	0	0	0	0	0
Subcontracting, BA	*	0	0	0	0	0	0
Procurement, BA	0	0	0	0	0	0	0
Capital equipment, BA	0	0	0	0	0	0	0
Direct personnel, FTE	0	0	0	0	0	0	0
Emergency Energy Conservation Planning (DK 07 00)							
Operating							
BO	0.5	0.2	0.2	0.2	0.2	0.2	0.2
BA	0.6	0.2	0.2	0.2	0.2	0.2	0.2
Subcontracting, BA	0.2	0.1	0	0	0	0	0
Procurement, BA	0	0	0	0	0	0	0
Capital equipment, BA	*	0	0	0	0	0	0
Direct personnel, FTE	2	3	2	2	2	2	2

[a]Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. An asterisk indicates funding of less than $50,000. Because of rounding, the sum of the individual costs for a given year may not equal the total shown.

[b]Budget outlay.

[c]Budget authorization.

[d]Full-time equivalent (FTE) person-years.

Table B.9[a] (continued)

	Fiscal year						
	'79	'80	'81	'82	'83	'84	'85
Utility Regulatory Assistance (DK 08 01)							
Operating							
BO	0.8	0.6	0.4	0.4	0.4	0.4	0.4
BA	1.0	0.6	0.4	0.4	0.4	0.4	0.4
Subcontracting, BA	0.7	0.1	0.1	0.1	0.1	0.1	0.1
Procurement, BA	0	0	0	0	0	0	0
Capital equipment, BA	*	0	0	0	0	0	0
Direct personnel, FTE	2	6	3	3	3	3	3
Total, Economic Regulatory Administration							
Operating							
BO	1.4	0.8	0.6	0.6	0.6	0.6	0.6
BA	3.0	0.7	0.6	0.6	0.6	0.6	0.6
Subcontracting, BA	0.2	0.2	0.1	0.1	0.1	0.1	0.1
Procurement, BA	0	0	0	0	0	0	0
Capital equipment, BA	*	0	0	0	0	0	0
Direct personnel, FTE	5	9	5	5	5	5	5
Policy and System Studies (KK 10)							
Operating							
BO	0.6	0.4	0.5	0.3	0.3	0.3	0.3
BA	0.5	0.4	0.5	0.3	0.3	0.3	0.3
Subcontracting, BA	0.3	0.1	0.2	*	*	*	*
Procurement, BA	0	0	0	0	0	0	0
Capital equipment, BA	0	*	*	*	*	*	*
Direct personnel, FTE	9	4	4	4	4	3	3
Strategic Petroleum Reserve (EB 10)							
Operating							
BO	0.1	0.3	0.3	0.3	0.3	0.3	0.3
BA	0.1	0.3	0.3	0.3	0.3	0.3	0.3
Subcontracting, BA	*	*	0.1	0.1	0.1	0.1	0.1
Procurement, BA	*	*	*	*	*	*	*
Capital equipment, BA	0	0	0	0	0	0	0
Direct personnel, FTE	1	3	2	2	2	2	2

[a]Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. An asterisk indicates funding of less than $50,000. Because of rounding, the sum of the individual costs for a given year may not equal the total shown.

Table B.10. Summary of resources – DOE reimbursements[a]

	Fiscal year						
	'79	'80	'81	'82	'83	'84	'85
Nuclear Waste Management[b]							
Operating							
BO[c]	2.3	9.2	13.5	15.5	17.5	20.0	22.0
BA[d]	2.4	9.2	13.5	15.5	17.5	20.0	22.0
Subcontracting, BA[e]							
Procurement, BA[e]							
Capital equipment, BA[e]							
Direct personnel, FTE[f]	19	94	99	108	113	118	126
Fuel Cycle Research and Development[g]							
Operating							
BO	4.3	0.5	0.5	0.5	0.5	0.5	0.5
BA	4.5	0.5	0.5	0.5	0.5	0.5	0.5
Subcontracting, BA	0.1	0	0	0	0	0	0
Procurement, BA	0.8	0	0	0	0	0	0
Capital equipment, BA	0.2	0	0	0	0	0	0
Direct personnel, FTE	57	5	5	5	5	5	5
Other Fission							
Operating							
BO	3.8	4.6	5.6	6.0	6.0	6.0	6.0
BA	3.8	4.6	5.6	6.0	6.0	6.0	6.0
Subcontracting, BA	0.5	0	0	0	0	0	0
Procurement, BA	0.4	0	0	0	0	0	0
Capital equipment, BA							
Direct personnel, FTE	33	45	53	53	53	53	53
Fossil Energy (Solvent Refined Coal and H-Coal)							
Operating							
BO	0.8	2.0	2.0	2.0	2.0	2.0	2.0
BA	0.8	2.0	2.0	2.0	2.0	2.0	2.0
Subcontracting, BA	0						
Procurement, BA	0.3						
Capital equipment, BA							
Direct personnel, FTE	3	8	8	8	8	8	8
Solar Energy Research Institute (Regional Employment, Solar Plasma Coatings)							
Operating							
BO	*	0.1	0.1	0.1	0.1	0.1	0.1
BA	*	0.1	0.1	0.1	0.1	0.1	0.1
Subcontracting, BA	0	*	*	*	*	*	*
Procurement, BA	0	0	0	0	0	0	0
Capital equipment, BA	0	0	0	0	0	0	0
Direct personnel, FTE	1	1	1	1	1	1	1

[a]Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. An asterisk indicates funding of less than $50,000. Because of rounding, the sum of the individual costs for a given year may not equal the total shown.

[b]Because of their strong links to the ET program, these figures are repeated under Activities AG 30 and JM 05 in the summary of resources for the Assistant Secretary for Energy Technology.

[c]Budget outlay.

[d]Budget authorization.

[e]The combined figures for the two activities for this program (AG 30 and JM 05) are given in the summary of resources for the Assistant Secretary for Energy Technology.

[f]Full-time equivalent (FTE) person-years.

[g]Because of their strong links to the ET program, these figures are repeated under Subactivity AG 20 40 in the summary of resources for the Assistant Secretary for Energy Technology.

Table B.10[a] (continued)

	Fiscal year						
	'79	'80	'81	'82	'83	'84	'85
Argonne National Laboratory (Environmental Impact of Fuel Use Act, Integrated Community Energy Systems Market Penetration, and Characterization of Process Streams)							
Operating							
BO	0.1	1.3	1.3	1.1	1.0	1.0	1.0
BA	0.1	1.3	1.3	1.1	1.0	1.0	1.0
Subcontracting, BA	*	0.1	0.1	0	0	0	0
Procurement, BA	0	0	0	0	0	0	0
Capital equipment, BA	0	0	0	0	0	0	0
Direct personnel, FTE	1	9	7	6	5	5	5
Oak Ridge Operations Office/Technical Information Center Numerical Data Studies							
Operating							
BO	0.1	0.1	0.1	0.1	0.1	0.1	0.1
BA	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Subcontracting, BA	0	0	0	0	0	0	0
Procurement, BA	0	0	0	0	0	0	0
Capital equipment, BA	0	0	0	0	0	0	0
Direct personnel, FTE	0	1	1	1	1	1	1
Other DOE reimbursements							
Operating							
BO	6.9	7.8	4.2	3.2	2.5	1.9	1.4
BA	6.9	7.8	4.2	3.2	2.5	1.9	1.4
Subcontracting, BA	0.7						
Procurement, BA	0.6						
Capital equipment, BA	0						
Direct personnel, FTE	31	43	28	27	26	20	14
Total, DOE reimbursements							
Operating							
BO	18.3	25.6	27.3	28.5	29.7	31.6	33.1
BA	18.6	25.6	27.3	28.5	29.7	31.6	33.1
Subcontracting, BA	1.3	0.1	0.1	0	0	0	0
Procurement, BA	2.1	0	0	0	0	0	0
Capital equipment, BA	0.2	0	0	0	0	0	0
Direct personnel, FTE	146	206	202	209	212	211	213

[a]Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. An asterisk indicates funding of less than $50,000. Because of rounding, the sum of the individual costs for a given year may not equal the total shown.

Table B.11. Summary of resources – Nuclear Regulatory Commission[a]

	Fiscal year						
	'79	'80	'81	'82	'83	'84	'85
Reactor Safety Research							
Operating							
BO[b]	17.2	17.7	12.0	11.5	11.7	12.0	12.5
BA[c]	17.2	17.7	12.0	11.5	11.7	12.0	12.5
Subcontracting, BA	1.0	0.6	0.4	0.4	0.4	0.4	0.4
Procurement, BA	2.0	2.9	1.6	1.6	1.6	1.6	1.6
Capital equipment, BA	0.9	1.2	0.5	0.5	0.5	0.5	0.5
Direct personnel, FTE[d]	161	150	114	100	101	101	103
Safeguards, Fuel Cycle, and Environmental Research							
Operating							
BO	2.1	2.5	2.5	2.5	2.5	2.5	2.5
BA	2.1	2.5	2.5	2.5	2.5	2.5	2.5
Subcontracting, BA	0.5	0.3	0.2	0.2	0.2	0.2	0.2
Procurement, BA	0.1	0.5	0.6	0.6	0.6	0.6	0.6
Capital equipment, BA							
Direct personnel, FTE	10	12	12	11	11	11	10
Office of Standards Development							
Operating							
BO	0.7	0.7	0.7	0.7	0.7	0.7	0.7
BA	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Subcontracting, BA	*	*	*	*	*	*	*
Procurement, BA	*	*	*	*	*	*	*
Capital equipment, BA							
Direct personnel, FTE	7	8	7	7	7	7	7
Office of Nuclear Material Safety and Safeguards							
Operating							
BO	1.3	1.9	2.0	2.1	2.3	2.5	2.5
BA	1.3	1.9	2.0	2.1	2.3	2.5	2.5
Subcontracting, BA	0.2	0.4	0.4	0.4	0.4	0.4	0.4
Procurement, BA	0	0	0	0	0	0	0
Capital equipment, BA							
Direct personnel, FTE	9	15	15	15	15	15	15
Office of Nuclear Reactor Regulation							
Operating							
BO	2.0	2.0	2.5	2.5	2.5	2.5	2.5
BA	2.0	2.0	2.5	2.5	2.5	2.5	2.5
Subcontracting, BA	0.1	0.1	0.4	0.5	0.5	0.5	0.5
Procurement, BA	0	0	0	0	0	0	0
Capital equipment, BA							
Direct personnel, FTE	26	20	22	22	21	21	20

[a]Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. An asterisk indicates funding of less than $50,000. Because of rounding, the sum of the individual costs for a given year may not equal the total shown.

[b]Budget outlay.

[c]Budget authorization.

[d]Full-time equivalent (FTE) person-years.

Table B.11[a] (continued)

	Fiscal year						
	'79	'80	'81	'82	'83	'84	'85
Other NRC							
Operating							
BO	0.4	0.4	0.4	0.4	0.4	0.4	0.4
BA	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Subcontracting, BA	0	0	0	0	0	0	0
Procurement, BA	0	0	0	0	0	0	0
Capital equipment, BA							
Direct personnel, FTE	4	5	5	5	5	5	5
Total, NRC							
Operating							
BO	23.7	25.2	20.1	19.7	20.1	20.6	21.1
BA	24.5	25.2	20.1	19.7	20.1	20.6	21.1
Subcontracting, BA	1.8	1.4	1.4	1.5	1.5	1.5	1.5
Procurement, BA	2.2	3.4	2.2	2.2	2.2	2.2	2.2
Capital equipment, BA							
Direct personnel, FTE	217	210	175	160	160	160	160

[a]Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. An asterisk indicates funding of less than $50,000. Because of rounding, the sum of the individual costs for a given year may not equal the total shown.

Table B.12. Summary of resources – Non-DOE Programs (excluding NRC)[a]

	Fiscal year						
	'79	'80	'81	'82	'83	'84	'85
Other federal agencies (Life Sciences)							
Operating							
BO[b]	13.2	15.0	16.0	16.5	17.0	17.5	18.0
BA[c]	13.2	15.0	16.0	16.5	17.0	17.5	18.0
Subcontracting, BA	0.3						
Procurement, BA	1.0						
Capital equipment, BA	*						
Direct personnel, FTE[d]	173	180	183	185	187	193	200
Other federal agencies (Fission)							
Operating							
BO	0.5	1.4	1.5	1.6	1.6	1.6	1.6
BA	0.5	1.4	1.5	1.6	1.6	1.6	1.6
Subcontracting, BA	0	0	0	0	0	0	0
Procurement, BA	0.5	0	0	0	0	0	0
Capital equipment, BA	0	0	0	0	0	0	0
Direct personnel, FTE	0	10	10	10	10	10	10
Defense Civil Preparedness Agency (Expedient Shelters and Radiological Defense)							
Operating							
BO	0.1	0.1	0.1	0.1	0.1	0.1	0.1
BA	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Subcontracting, BA	0	0	0	0	0	0	0
Procurement, BA	0	0	0	0	0	0	0
Capital equipment, BA	0	0	0	0	0	0	0
Direct personnel, FTE	1	1	1	1	1	1	1
Economic Development Administration (Energy Availabilities)							
Operating							
BO	0.1	0.1	0.1	0.1	0.1	0.1	0.1
BA	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Subcontracting, BA	*	*	*	*	*	*	*
Procurement, BA	0	0	0	0	0	0	0
Capital equipment, BA	0	0	0	0	0	0	0
Direct personnel, FTE	1	1	1	1	1	1	1
Department of Housing and Urban Development (Modular Integrated Utility Systems)							
Operating							
BO	0	0.2	0.1	0	0	0	0
BA	0	0	0	0	0	0	0
Subcontracting, BA	0	0.1	*	0	0	0	0
Procurement, BA	0	0	0	0	0	0	0
Capital equipment, BA	0	0	0	0	0	0	0
Direct personnel, FTE	0	1	*	0	0	0	0

[a]Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. An asterisk indicates funding of less than $50,000. Because of rounding, the sum of the individual costs for a given year may not equal the total shown.

[b]Budget outlay.

[c]Budget authorization.

[d]Full-time equivalent (FTE) person-years.

Table B.12[a] (continued)

	Fiscal year						
	'79	'80	'81	'82	'83	'84	'85
Other non-DOE							
Operating							
BO	4.7	4.2	3.1	3.2	3.7	3.7	3.7
BA	4.7	4.4	3.1	3.2	3.7	3.7	3.7
Subcontracting, BA	0.3						
Procurement, BA	0.2						
Capital equipment, BA	*						
Direct personnel, FTE	44	57	39	43	48	48	48
Total, non-DOE excluding NRC							
Operating							
BO	18.6	21.0	20.9	21.5	22.5	23.0	23.5
BA	18.6	21.0	20.9	21.5	22.5	23.0	23.5
Subcontracting, BA	0.6	*	*	*	*	*	*
Procurement, BA	1.7	0	0	0	0	0	0
Capital equipment, BA	*	0	0	0	0	0	0
Direct personnel, FTE	219	250	234	240	247	253	260

[a]Funding for FY 1979 through FY 1981 is in millions of current dollars and reflects a 7% escalation factor; funding for FY 1982 through FY 1985 is in millions of constant 1981 dollars. An asterisk indicates funding of less than $50,000. Because of rounding, the sum of the individual costs for a given year may not equal the total shown.

Table B.13. Proposed and approved construction items in order of priority for each fiscal year

Project	Total estimated cost (millions of dollars)	Budget authorization (millions of dollars)						
		'79	'80	'81	'82	'83	'84	'85
Pre–FY 1979 projects (with FY 1979 funding)								
Intermediate-Level Waste Management Facilities (JM)	14.0	1.0						
Advanced Fuel Recycle Integrated Equipment Test Facility (AG)	15.4	6.0	6.4					
Solid Waste Processing Facility (SWPF), plant engineering and design	2.9	0.4						
Programmatic facilities funded for FY 1979								
Aquatic Ecology Laboratory (GK)	1.6	1.6						
Holifield Heavy Ion Research Facility (HHIRF) – Phase II, plant engineering and design	0.4	0.4						
Upgrading 86-in. Cyclotron for Biomedical Radioisotopes (GK)	0.5	0.5						
Programmatic facilities proposed for FY 1980								
Upgrading Laboratories to Handle Hazardous Materials	1.5		1.5					
Improvements to Radioactive Waste Facilities, plant engineering and design	2.0		2.0					
SWPF, plant engineering and design	1.5		1.5					
HHIRF – Phase II, plant engineering and design	0.8		0.8					
Programmatic facilities proposed for the FY 1981 budget								
High Temperature Materials Laboratory (HTML), architect engineering and long lead procurement	3.0			3.0				
Improvements to Radioactive Waste Facilities	13.5			13.5				
Toxic Substances Laboratory and Animal Facility	16.5			2.4	14.1			
Upgrading of Laboratories, Offices, and Support Facilities of the Fusion Energy Division at Y-12	7.6			7.6				
Modernization of Laboratories for Study of Environmental Pollutants	2.1			2.1				
Accelerator and Reactor Improvement Project – EN Tandem	0.6			0.6				
Accelerator and Reactor Improvement Project – HHIRF	0.7			0.7				
Hot Experimental Facility, construction in FY 1984 at a total estimated cost of $0.5 to $1 billion	60.0			20.0	40.0			
Programmatic facilities proposed for the FY 1982 budget								
HTML	24.5				24.5			
SWPF	33.0				33.0			
Mutagenesis Screening and Testing Facility for Synthetic Fuels – Building 9769, 2d Floor	1.8				1.8			
Mammalian Genetics Facility – Building 9210	6.0					6.0		
Hazardous Waste Incinerator Facility	1.3					1.3		
Accelerator and Reactor Improvement Project – HHIRF	0.5						0.5	
Improvements to Engineering Technology Facilities	9.0						9.0	
Chemical Toxicology Facilities	13.7						13.7	
General-purpose facilities proposed for the FY 1981 budget								
Energy Systems Research Laboratory (ESRL), architect engineering only	2.0			2.0				
Upgrade ORNL Primary Substation	3.5			3.5				
Water Pollution Control – ORNL	10.0			10.0				
Energy Management System	4.0			4.0				

Table B.13 (continued)

Project	Total estimated cost (millions of dollars)	Budget authorization (millions of dollars)						
		'79	'80	'81	'82	'83	'84	'85
General-purpose facilities proposed for the FY 1982 budget								
ESRL	18.0				18.0			
Environmental and Effluent Monitoring Systems Upgrade	8.1				8.1			
Modifications Aimed at Compliance with the Occupational Safety and Health Act	3.8				3.8			
Materials Warehousing Upgrade	3.3				3.3			
Improvements in Fire Protection	2.8				2.8			
Information Resource Center for Energy and the Environment	11.0				11.0			
Laboratory Control Center	2.6				2.6			
General-purpose facilities proposed for beyond the FY 1982 budget								
Primary Electrical Distribution System Restoration	2.5					2.5		
Central Chilled Water System Restoration	2.0					2.0		
Renovate Heating, Ventilation, and Air Conditioning Systems in Four Heavy Engineering Laboratories	21.8					21.8		
Primary Water Mains Restoration	4.4						4.4	
Alternate Water Supply	2.7						2.7	
Maintenance Facilities	4.9						4.9	
Machine Shop Facilities	6.0						6.0	
General Analytical Laboratory Renovation	1.4						1.4	
General Engineering Facility	5.5							5.5
General Laboratories Replacement	7.6							7.6
Multiprogram Support Shop Facilities	1.4							1.4
Personnel Service Facilities	1.4							1.4
Main Laboratory Access and Parking	1.4							1.4
General-purpose equipment (GPE)								
General-Purpose Capital Equipment		1.6	2.3	2.4	3.5	3.5	3.5	4.0
General-Purpose Automated Data Processing Equipment		0.4	1.2	10.9	1.0	1.0	1.0	1.0
Subtotal		2.0	3.5	13.3	4.5	4.5	4.5	5.0
General plant projects (GPP)								
		3.1	4.8	6.3	6.0	6.0	6.0	6.0

DOE Headquarters feedback to Table B.13

Project	*Total estimated cost (millions of dollars)*	*Budget authorization (millions of dollars)*						
		'79	*'80*	*'81*	*'82*	*'83*	*'84*	*'85*
Programmatic facilities proposed for the FY 1981 budget								
Upgrading of Laboratories, Offices, and Support Facilities of the Fusion Energy Division at Y-12	*7.6*			~~*7.6*~~	*7.6*			
General-purpose facilities proposed for the FY 1981 budget								
Water Pollution Control – ORNL	*10.0*			~~*5.0*~~	*5.0*			
Energy Management System	*4.0*			~~*4.0*~~	*4.0*			

ORNL Response: The "Water Pollution Control — ORNL" item is in the ORNL budget as an FY 1981 project. The Energy Management System is urgently being considered as a possible FY 1981 project at the request of the Oak Ridge Operations Office (ORO) (R. J. Hart, ORO, letter to R. F. Hibbs, Union Carbide Corporation, Nuclear Division, Apr. 16, 1979).

Appendix C
R&D

Table C.1. Summary of the functional phase of research and development in major program areas[a]

	Fiscal year		
	'79	'80	'81
Assistant Secretary for Energy Technology			
Basic research	0.6	0.7	1.0
Applied research	18.5	19.8	19.2
Exploratory development	36.9	36.7	39.2
Technology development	59.3	59.5	78.0
Engineering development	12.2	14.9	25.9
Other	2.6	3.6	13.6
Subtotal	129.8	155.0	176.8
Director of Energy Research			
Basic research	24.7	28.0	31.3
Applied research	14.4	15.9	17.7
Exploratory development	1.0	1.1	1.2
Subtotal	40.0	45.0	50.2
Assistant Secretary for the Environment			
Basic research	9.0	10.0	10.7
Applied research	15.2	16.8	17.9
Exploratory development	2.0	2.3	2.5
Technology development	3.0	3.3	3.6
Engineering development	0.3	1.0	1.1
Subtotal	29.6	33.5	35.7
Assistant Secretary for Conservation and Solar Applications			
Basic research	0.1	0.2	0.2
Applied research	1.8	3.7	2.6
Exploratory development	2.1	4.5	4.3
Technology development	3.3	6.8	6.7
Engineering development	0.6	1.7	2.8
Subtotal	7.9	16.9	16.5
Total	207.3	250.4	279.2

[a]The funding in this table, which is given in millions of current dollars and reflects a 7% escalation factor, is for budget outlays. Because of rounding, the sum of the individual costs for a given year may not equal the total shown.

Appendix D
Reference

A/S	B&R CODE	WPAS#	TITLE
ASET	AA 1003 030	00116	BENEFIC OF DRY PULVERIZED COAL
ASET	AA 2003 014	00154	COAL LIQUEFACTION SUPPORT
ASET	AA 2003 021	00302	NEW LIQUEFACTION TECHNIQUES
ASET	AA 2003 021	00305	PHYS PROP OF COAL LIQUIDS
ASET	AA 2003 021	00307	TEXACO PROCESS ANALYSIS
ASET	AA 2003 021	00308	CRESAP FACILITY EVALUATION
ASET	AA 2003 021	00309	LIQUEFACTION MATERIALS RESEARCH
ASET	AA 2003 021	00312	ZINC CHLORIDE RECUP STUDY
ASET	AA 2003 021	NEW0017	V/L EQUILIBRIA FOR COAL LIQUIDS
ASET	AA 2003 021	NEW0018	SPECIAL ASSIGNMENT - GULF
ASET	AA 2003 021	NEW0019	SPECIAL ASSIGNMENT - EXXON
ASET	AA 2003 021	NEW0021	PROGRAM DEVEL-LIQUEFACTION
ASET	AA 2003 021	NEW0022	RECOV OF CATALYTIC & RESOURCES
ASET	AA 2003 021	NEW0023	ADV LIQUEFACTION DEVELOPMENT
ASET	AA 2003 021	NEW0024	AUTOMATED SEQ. ELUTION
ASET	AA 2003 021	NEW0025	IN-LINE H-DONOR MONITOR
ASET	AA 2003 022	00301	COAL SLURRY PREHEATERS
ASET	AA 2003 022	NOEW--1	COAL HANDLING & FEEDING TEST FAC
ASET	AA 2003 023	NEW0007	TECH SUPP-PERFORM ASSUR & STAND BR
ASET	AA 2003 024	00303	IN PLANT ENVIRONMENTAL MONITORS
ASET	AA 2003 024	00322	FOSSIL ENERGY ENVIRON PROJ.-ORO
ASET	AA 3002 010	NEW0015	FLUID BED SLURRY PREHEATER
ASET	AA 3002 010	NEW0016	PRESSURE LETDOWN IN PACKED BEDS
ASET	AA 3002 060	NEW0640	DATA MGT. FOR UMD GASIFIER
ASET	AA 3003 030	00097	EVAL OF HIGH BTU GASIF PROCESSES
ASET	AA 3003 050	NEW0009	EVAL OF ENVIRON CONT TECH
ASET	AA 3003 060	00095	ENGINEERING ECONOMICS STUDIES
ASET	AA 3004 030	00008	ENGR EVAL OF COAL CONV PROC
ASET	AA 3004 030	00042	PROC MODEL SUPT FOR COAL CONV PROC
ASET	AA 3004 030	00067	DESIGN & TECHNICAL SUPPORT
ASET	AA 3004 030	00075	FOSSIL ENERGY ENVIRON PROJ.-CHICAGO
ASET	AA 3004 030	00076	FOSSIL ENERGY ENVIRON PROJ.
ASET	AA 3004 030	00077	SURV OF INDUST EQUIP CAPABILITIES
ASET	AA 3004 030	00125	9 CR-1 MO STEELS FOR FOSS UTIL BOIL
ASET	AA 3004 030	00702	COAL EQUIPMENT TEST PROGRAM
ASET	AA 4001 000	00317	COAL COGEN/DIST HEAT PLT ASSESSM
ASET	AA 4002 000	00060	POTACCIUM VAPOR TOPPING CYCLE
ASET	AA 4003 000	00704	ADV PWR SYST PROG DEVELOPMENT
ASET	AA 5001 010	NEW0014	SUPERCHARGED FBC BOILER
ASET	AA 5001 010	NOEW--4	AFBC BOILER MTLS. TEST APPAR.
ASET	AA 5001 020	NEW0013	INDUSTRIAL FBC SUPPORT FOR METC
ASET	AA 5001 020	NEW0042	IN-BED EXPR FOR AFBC HEAT EXCH MAT
ASET	AA 5001 020	NEW0043	ERO/COR OF AFBC HEAT EXCH TUBES
ASET	AA 5001 020	NEW0045	ADVANCED SORBENT/FUEL FOR AFBC
ASET	AA 5001 030	00017	AFB COAL COMBUSTOR FOR COGEN
ASET	AA 5001 030	NEW0607	AFBC DEVELOPMENT
ASET	AA 5004 000	00311	IEA/EAS
ASET	AA 5004 000	NEW0026	PROC OF COAL CONV WASTES FOR DISP

A/S	B&R CODE	WPAS#	TITLE
ASET	AA 5005 020	NEW0027	PROC OF COAL COMB ASH FOR DISP
ASET	AA 6001 010	00066	CHEM & STRUCTURE OF COAL
ASET	AA 6001 010	00084	SYNTHETIC FUELS PROC RES DIGEST
ASET	AA 6002 000	NEW0603	CERAMICS-FOSSIL FUEL ENVIR.
ASET	AA 6003 000	NEW0002	THERMOMETRY MATLS COMPAT
ASET	AA 6003 000	NEW0003	THERMOMETRY SENSOR DEVELOPMENT
ASET	AA 6003 000	NEW0004	HEAT TRANSF & PROCESS DYNM
ASET	AA 6003 000	NEW0005	NOISE ANAL FOR FLUID BED COAL COMB
ASET	AA 6003 000	NEW0028	NATIONAL PROGRAM MANAGEMENT
ASET	AA 6003 000	NEW0041	PRESTRESSED CONCR PRESS VESS STDS
ASET	AA 6004 010	00300	PROC & PROG ANAL RES STUDIES
ASET	AA 6004 030	00316	SYSTEMS ANALYSIS SUPPORT
ASET	AA 8006 000	00080	IN SITU GASIFICATION PROC DEV
ASET	AB 1005 010	00075	CHEM FOR ENHANCED OIL RECOVERY
ASET	AB 1005 010	00086	SEL OF MULT TRAC-ENHANC OIL REC
ASET	AB 1005 010	00087	ION EXCH CHAR OF ENHANC OIL REC
ASET	AD 0201 000	00001	BIOMASS ENVIRON ASSESSMENT
ASET	AD 0201 000	00002	ECOSYS. OF WHOLE TREE HARVESTING
ASET	AD 0201 000	00018	DECENTRALIZED SOLAR ENERGY
ASET	AD 0201 000	NEW0048	NEUT DEPL FROM CROP RESIDUE REM
ASET	AD 0201 000	NEW0050	FUND STUDY-BIOPHOTOLYSIS OF WATER
ASET	AD 0301 000	00009	SMALL POWER SYSTEMS ANAL
ASET	AD 0301 000	00011	HIGH TEMP APPLICATIONS
ASET	AD 0301 000	00016	MISSISSIPPI CO COMM COLLEGE
ASET	AD 0301 000	00017	NW MISSISSIPPI JUNIOR COLLEGE
ASET	AD 0302 000	NEW0081	LASER-PHOTOVOLTAIC CONVERSION
ASET	AD 0302 000	NEW0082	LASER-SOLAR CELL FABRICATION
ASET	AD 0304 000	00008	OTEC HEAT EXCHANGERS
ASET	AD 0304 000	00013	OTEC ALTERN CYCLES DEVEL
ASET	AE 3001 020	00003	WASTE HEAT REJECTION
ASET	AE 3001 050	00004	ENV ANAL OF GEOTHERMAL ENGY
ASET	AF 0110 110	00002	CONFINEMENT-TOKAMAK SYS RES OPER
ASET	AF 0110 110	00126	REB INJECTION INTO ISX-B
ASET	AF 0110 12E	00101	CONF-BEAM LINE MODIF 100A SOURCE
ASET	AF 0110 12E	00102	CONF-TOKAMAK SYS-ISX BUND DIV EXP
ASET	AF 0110 12E	00120	CONF-ELECTRON CYCL HEATING EXPR
ASET	AF 0110 12E	00125	MDF-1 MW RF PLASMA HEATING (ECH)
ASET	AF 0110 12J	00103	CONF-TOK SYS-PDX NEUTRAL BEAM
ASET	AF 0110 12N	NOEW--3	LONG PULSE TOKAMAK MDF
ASET	AF 0210 111	00010	D&T-MS-SMDP-12 TESLA COILS
ASET	AF 0210 111	00131	D&T SUPER MAGNET-EBT II COILS
ASET	AF 0210 112	00056	D&T-MS-SMDP-ADV CONDUCTOR DEV
ASET	AF 0210 113	00011	D&T-MS-SMDP-LARGE COIL PROGRAM
ASET	AF 0210 113	00012	D&T-MS-SMDP-LARGE COIL TEST FACIL
ASET	AF 0210 113	00122	D&T-MS-SMDP-LARGE COIL PROG-R&D ACT
ASET	AF 0220 210	NOEW--2	D&T NEUTRAL BEAM ADV. DEVELOPMENT
ASET	AF 0220 211	00017	D&T-NEUT BEAM R&D BASE PROG
ASET	AF 0220 212	00054	D&T-NBR&D-MAJOR DEV FABR OPER

A/S	B&R CODE	WPAS#	TITLE
ASET	AF 0220 220	00021	D&T-ALTERN HEATING-MICROWAVE DEV
ASET	AF 0220 240	00022	D&T-PART HANDLING TECHNOLOGY
ASET	AF 0220 250	00023	D&T-PLASMA MAINT & CONT-PELLET FUEL
ASET	AF 0230 310	00025	ALLOY DEV FOR FUSION REACT APPL
ASET	AF 0230 320	00027	D&T-IMPURITY STUDY PROGRAM
ASET	AF 0230 330	00032	RAD EFF-INSUL FOR SUPERCOND MAG
ASET	AF 0230 340	00033	DAMAGE ANAL AND DOSIMETRY
ASET	AF 0230 352	00034	RAD FACILITIES OPERATION
ASET	AF 0240 410	00035	CONF-DESIGN & ENGR-ENGR TEST FAC
ASET	AF 0240 420	00037	D&T-ERT REACTOR STUDY
ASET	AF 0240 420	00121	TOKAMAK BURN PULSE EXTENSION
ASET	AF 0240 431	00036	DEMONSTRATION REA STUDIES
ASET	AF 0240 431	00039	MFE-RSIC
ASET	AF 0240 431	00041	D&T-FSE-FPDS-TOKAMAK BLANKET
ASET	AF 0240 450	00044	D&T-FSE-PLASMA SYSTEMS ANAL
ASET	AF 0240 460	00057	D&T-FSE-CONTROL & INSTRUMENTATION
ASET	AF 0250 510	00043	TRITIUM PERMEATION & STEAM GENER
ASET	AF 0281 031	1	FUEL FAB.-ORR-INVENTORY CHANGE
ASET	AF 0310 110	00008	CONF-MAGNETIC MIRROR SYST-EBTS
ASET	AF 0310 110	00009	EBT-II PROJECT
ASET	AF 0310 123	00127	EBT-II PROOF OF PRINCIPLE
ASET	AF 0310 123	00130	ALTERNATE CONCEPTS-EBTS UPGRADE
ASET	AF 0320 000	00046	APPL PLASMA PHY-FUS PLASMA THEORY
ASET	AF 0320 000	00115	EBT THEORY ADDITION
ASET	AF 0330 320	00048	APP-EXPR RES-CONT FUS ATOM DAT CTR
ASET	AF 0330 320	00049	APP PLAS PHY-PLAS MEAS-DIAG OF HI-T
ASET	AF 0330 320	00050	APP PLAS PHY-EXPR RES-EXP ATOM
ASET	AF 0340 420	00052	USER SERV CENTER COMP OPER
ASET	AG 1020 412	OH044	ORNL LOA 2 TASKS--THORS
ASET	AG 1020 413	OH154	LOA-3 ENERGETICS ACCOMODATION
ASET	AG 1020 414	OH107	ORNL LOA 4 TSKS-ENV ASSMT ACT FUELS
ASET	AG 1020 414	OH155	ORNL LOA 4 TSKS-MOD EV REA REL
ASET	AG 1020 415	OH020	ORNL LOA SUP & INTEGR NSIC
ASET	AG 1020 415	OH143	LOA INTEGRATION - CREDO
ASET	AG 1020 415	OH156	LOA INTEGRATION - SACRD
ASET	AG 1020 421	OH016	MEASUREM & CONT TECH DEV
ASET	AG 1020 424	OH048	HIGH-TEMP STRUCTURAL DESIGN
ASET	AG 1020 424	OH062	NDT FOR ALT STEAM GEN DESIGN
ASET	AG 1020 424	OH103	EVAL OF LG-DIAM PIPE & FITTINGS
ASET	AG 1020 430	OH004	FAST REACTOR SHIELDING EXPR
ASET	AG 1020 430	OH013	CROSS SECT FOR REACTOR MATLS
ASET	AG 1020 430	OH015	RADIATION SHIELD INFO CTR (RSIC)
ASET	AG 1020 430	OH054	METH DEV SENS ANAL-INT EXP TESTS
ASET	AG 1020 430	OH057	SHIELDING ANALYSIS
ASET	AG 1020 430	OH153	US/UK PFR ACTINIDE IRRADIATIONS
ASET	AG 1020 450	OH024	JOINING DEVELOPMENT
ASET	AG 1020 450	OH038	DEV OF FERRITIC 9% CR ALLOY
ASET	AG 1020 450	OH050	MECH PROP OF REFERENCE MATLS

A/S	B&R CODE	WPAS#	TITLE
ASET	AG 1020 450	OH061	NONDESTRUCTIVE TESTING
ASET	AG 1020 460	OH037	CLAD/DUCT DEVELOPMENT
ASET	AG 1020 470	OH147	GEL-SPHERE-PAC FUEL DEV
ASET	AG 1030 100	01350	PCRV CLOSURES & LINER
ASET	AG 1030 100	01351	SHIELDING & PHYSICS
ASET	AG 1030 200	01352	CORE FLOW TEST LOOP
ASET	AG 1040 301	OH142	TRANSFER OF BRP INFORMATION
ASET	AG 1040 302	OH148	INFCE
ASET	AG 1081 036	2	FUEL FAB.-TSF-INVENTORY CHANGE
ASET	AG 2010 000	NEW0002	HISTORICAL ANAL OF LWR FUEL UTIL
ASET	AG 2030 010	01329	HTGR CHEMISTRY
ASET	AG 2030 010	01330	FUELED GRAPHITE DEVELOPMENT
ASET	AG 2030 010	01331	PCRV DEVELOPMENT
ASET	AG 2030 010	01332	GCR STRUCTURAL MATLS STUDIES
ASET	AG 2030 010	01333	HTGR GRAPHITE STUDIES
ASET	AG 2030 010	01441	PEBBLE-BED REACTOR EVALUATIONS
ASET	AG 2040 0XX	OH04X	CONSOLIDATED FUEL RECYCLE
ASET	AG 2060 042	OH022	NUCLEAR STANDARDS
ASET	AG 3020 010	ONLWHXX	HIGH LEVEL WASTE-COMM.
ASET	AG 3020 020	ONLWLXX	LOW LEVEL WASTE MGMT-COMM.
ASET	AG 3020 030	ONLWT01	VOL RED OF CONT METAL WASTE
ASET	AG 3020 040	ONLWAXX	HIGH LEVEL WASTE TESTS
ASET	AG 4020 014	02312	THERMOELECTRIC CONVERTER SUPPORT
ASET	AG 4020 014	02313	SOLAR-POLAR MISSION MATERIALS
ASET	AG 4020 023	01410	DYNAMIC ISOTOPE POWER SYSTEM SUPPOT
ASET	AG 4020 030	01322	SPACE FLIGHT SYSTEMS HARDWARE
ASET	AG 4020 060	01367	TERRESTRIAL RADIOISOTOPE APPL
ASET	AG 4020 060	01495	SYSTEMS TECHNOLOGY SUPPORT
ASET	AG 4020 060	02314	ISOTOPE FUEL COMPATIBILITY
ASET	AG 4030 010	01303	STUDIES AND EVALUATIONS
ASET	AG 4030 020	01307	SUPPORT FOR ENERGY CENTER STUDIES
ASET	AG 4030 020	01308	METEOROLOGICAL EFFECTS
ASET	AG 4030 020	01310	DESALTING
ASET	AG 4030 020	01311	ASSESSMENT OF PROCESS APPL
ASET	AG 4030 020	01313	WASTE HEAT UTILIZATION
ASET	AG 4030 020	01477	DISTRICT HEATING ENVIRONMENTAL
ASET	AG 4030 020	01478	DISTRICT HEATING STUDIES
ASET	AG 4030 030	01446	NASAP ENVIRONMENTAL
ASET	AG 4030 030	01447	NASMA TECHNICAL OVERVIEW
ASET	AG 4030 030	01480	ASSESSMENT OF DENATURED TH CYC
ASET	AG 4081 055	3	OSM-IRIDIUM-INVENTORY CHANGE
ASEV	AG 7001 010	800006	SURVEILLANCE
ASEV	AG 7001 010	800007	SURP FAC SURVEILLANCE-FPDL
ASEV	AG 7001 010	800008	SURVEIL OF SURPLUS FAC-PRE OCT-1976
ASEV	AG 7001 030	800195	PLAN FOR DISP OF SURPLUS FAC
ASEV	AG 7001 040	800097	FPDL DECOMMISSIONING
ASEV	AG 7001 040	NOEW-01	D&D OF SURP FAC EXCL REAC
ASEV	AG 7001 040	NOEW-02	DISP OF SURPL FAC - LITR

A/S	B&R CODE	WPAS#	TITLE
ASEV	AG 7002 000	600036	RADIOL SURV OF INACT URAN MILLS
ASEV	AG 7002 000	800378	U ORE &/OR TAILINGS TREATM
ASEV	AG 7004 000	600020	RADIOL SURV OF EXC AEC/MED PROP
ASEV	AG 7004 000	800309	FUSRAP-EIS ASSISTANCE
ASEV	AG 7004 000	800384	TECH ASSIST FOR ENGR & ENV STUDIES
ASET	AJ 0100 000	00001	MGMT SUP-FUELS FROM WOODY BIOMASS
ASET	AJ 0100 000	NEW0052	FUELS FROM EUTROPHIC FRESH WATERS
ASET	AJ 0100 000	NEW0053	HYDROPYROLYSIS VS PYROLYSIS
ASET	AJ 0100 000	NEW0610	FEEDSTOCKS FROM RENEWABLE BIOMASS
DER	AK 0101 011	00001	LIGHT ION NUCLEAR PHYSICS
DER	AK 0101 011	00004	BASIC NEUTRON PHYSICS RES
DER	AK 0101 012	00005	OPERATIONS - ORELA
DER	AK 0101 012	00006	NUCL DATA FOR FUS & FISS REACTORS
DER	AK 0101 012	00008	ACTINIDE NEUTRON CROSS SECTION
DER	AK 0101 012	00009	ELECTRON FUEL PROD PHYS STUDIES
DER	AK 0101 012	00010	ONE-ATOM DET-SOLAR NEUTRINO MEAS
DER	AK 0101 013	00002	NUCLEAR DATA PROJECT
DER	AK 0101 014	00012	CHEM OF TRANSURANIUM ELE & COMP
DER	AK 0101 021	00013	ELECTROMAGNETIC ISOTOPE SEPARATION
DER	AK 0101 022	00014	HFIR OPERATIONS SUPPORT
DER	AK 0101 022	00015	TRANSURANIUM ELEMENT PROCESSING
DER	AK 0101 022	00016	DIST OF SPEC ISOT FOR RESEARCH
DER	AK 0101 022	00017	R&D-ISOTOPE RES MATLS PREP
DER	AK 0101 022	NOEW-01	RES MATLS COLLECTION LOAN PROG
DER	AK 0102 011	00018	STRUC OF MTLS FOR ENERGY SYSTEMS
DER	AK 0102 011	00019	X-RAY RES USING SYNCHROTRON SRCS
DER	AK 0102 011	00020	ANAL HIGH VOLTAGE ELECT MICROSCOPY
DER	AK 0102 012	00021	DEFORM & MECH BEH OF STRUC MTLS
DER	AK 0102 013	00022	SOLID STATE REACT & PHYS PROP
DER	AK 0102 014	00023	RADIATION EFFECTS
DER	AK 0102 015	00024	FUNDAMENTALS OF WELDING & JOINING
DER	AK 0102 015	00025	STUDIES IN NONDESTRUC EVALUATION
DER	AK 0102 015	00026	EROSION AND WEAR OF CERAMICS
DER	AK 0102 015	NOEW-02	LONG-RANGE ORD ALL (SEE AK010502)
DER	AK 0102 021	00027	INTERATOM INTERACT IN CONDENSED SYS
DER	AK 0102 021	00028	PROP OF DEFECTS
DER	AK 0102 021	NOEW-03	SUPPORT FOR NEUTRON USERS
DER	AK 0102 022	00031	PROP OF MTLS FOR ADV ENERGY SYST
DER	AK 0102 022	00032	PHOTOPHYS PROC OF SOLAR ENGY CONV
DER	AK 0102 022	00033	FUNDAMENTAL ASPECTS OF METAL FRACT
DER	AK 0102 022	00034	SOLID ELECT & SUPERIONIC COND
DER	AK 0102 022	00036	HI TEMP PROP-CARBIDES
DER	AK 0102 022	00038	SCATTERING OF SYNCHROTRON RAD
DER	AK 0102 023	00039	THEORY OF CONDENSED MATTER
DER	AK 0102 024	00040	RADIATION EFFECTS IN METALS
DER	AK 0102 024	00041	ION BOMBARD & NORM OF ION DMGE
DER	AK 0102 024	00044	GASES IN METALS
DER	AK 0102 025	00017	R&D-ISOTOPE RES MATLS PREP

A/S	B&R CODE	WPAS#	TITLE
DER	AK 0102 025	00042	SURFACE STUDIES & CATALYSIS
DER	AK 0102 025	00043	ION IMPLANTATION
DER	AK 0102 025	00144	RADIOACTIVE WASTE STORAGE
DER	AK 0102 025	00145	RAPID HEATING & COOLING PROCESSES
DER	AK 0102 031	00045	CHEM STRUC OF ENERGY RELATED MTLS
DER	AK 0102 032	00046	THERMODYN OF ENERGY RELATED SYST
DER	AK 0102 032	00047	CHEM ENGR RES (MATLS SCIENCE)
DER	AK 0102 032	00048	HI-TEMP CHEM & THERMO OF STRUC MTLS
DER	AK 0102 032	NOEW-04	PHYS TECH FOR RESOURCE RECOVERY
DER	AK 0102 032	NOEW-05	ENGR PROP OF FLUIDS AT EXTR COND
DER	AK 0102 032	NOEW-06	PLASMA CHEMISTRY
DER	AK 0102 033	00050	PHYS CHEM OF MOLTEN SALT ENGY UTIL
DER	AK 0102 033	00051	LOCAL CORR & STRS CRKNG REL TO ENGY
DER	AK 0103 011	00052	RADIATION CHEMISTRY
DER	AK 0103 011	00054	SURF EFF-HYDRO RECY CHEM
DER	AK 0103 011	NOEW-07	USE OF SYNCHROTRON RADIATION-ARPES
DER	AK 0103 012	00055	ATOMIC & MOL COLL DYNAMICS
DER	AK 0103 012	00056	PHOTOCH & PYRO REACT-ELEC SP RES
DER	AK 0103 012	00057	THEORETICAL CHEMISTRY
DER	AK 0103 013	00059	MERGED ELECTRON HEAVY ION BEAMS
DER	AK 0103 013	00060	COLLISIONS OF LOW ENERGY IONS
DER	AK 0103 013	00061	ACCELERATOR ATOMIC PHYSICS
DER	AK 0103 013	00063	THEORETICAL ATOMIC PHYSICS
DER	AK 0103 013	00064	EN TANDEM OPERATIONS
DER	AK 0103 021	00068	CHEM FISSION PRODUCT ELEMENTS
DER	AK 0103 021	00069	KINETICS OF ENZYME-CATAL PROC
DER	AK 0103 021	00070	INORG CHEM OF H CYCLES
DER	AK 0103 021	00071	AQ CHEM & THERMO TO ELEV T&P
DER	AK 0103 021	00072	COMPARATIVE INORGANIC CHEM
DER	AK 0103 021	00073	HETEROGEN CATAL OF ENGY SYST
DER	AK 0103 021	00074	ORG CHEM & CHEM OF FOSSIL FUELS
DER	AK 0103 021	00075	MOLTEN SALT CATAL FOR CHEM FUELS
DER	AK 0103 021	00186	STEAM GENERATOR CHEMISTRY
DER	AK 0103 021	NOEW-08	CHEM OF CO2 IN THE OCEANS
DER	AK 0103 022	00076	CHEM ENGR RES (CHEMICAL SCIENCE)
DER	AK 0103 022	00077	TRITIUM SEPARATION TECHNOLOGY
DER	AK 0103 022	00078	SEPARATIONS SYSTEMS RESEARCH
DER	AK 0103 022	00079	WASTE STREAM PROCESSING STUDIES
DER	AK 0103 022	00080	FUND CONCEPTS FOR RESOURCE RECOV
DER	AK 0103 022	00082	FUNDAMENTALS OF SEPR CHEMISTRY
DER	AK 0103 022	00083	SPECTROPHO STUDIES OF L ACTIVE MAT
DER	AK 0103 022	00084	FLOW THRU POROUS BODIES
DER	AK 0103 022	00085	MOLTEN SALT PROC-HI LEVEL WASTE
DER	AK 0103 022	00188	SEPR CHEM FOSSIL FUEL UTILIZATION
DER	AK 0103 022	00189	FUND PROC-SORP PUMPNG & TRANS OPER
DER	AK 0103 022	NOEW-09	ADV GAS PURIFICATION CONCEPTS
DER	AK 0103 023	00087	RD&D ADV CHEM MEASUREMENTS TECH
DER	AK 0103 023	00088	MASS SPEC R&D FOR INORG ACT ANAL

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DER	AK 0103 023	00089	IMMA R&D: SURFACE CHARACTERIZATION
DER	AK 0103 023	00090	MASS SPECT R&D ORGANIC ANALYSIS
DER	AK 0103 023	00091	ADV SPECT METH FOR CHEM ANALYSES
DER	AK 0103 023	00092	SPECTRO METH NON VOL ORGANIC SPEC
DER	AK 0103 024	NOEW-10	PROP HETEROGENEOUS SYSTEMS
DER	AK 0104 010	00100	SOLID-SOLIDS SEPR FOR RESO RECOVERY
DER	AK 0104 010	NOEW-11	EFF OF VIBR ENERGY ON AGGLO & DISP
DER	AK 0104 010	NOEW-12	OPTICAL MONITORS-ADV PROC INST
DER	AK 0104 010	NOEW-13	ENGR PRINC OF IN-SITU SOLUT MINING
DER	AK 0104 010	NOEW-14	REC OF METALS CRIT TO ENERGY UTIL
DER	AK 0104 010	NOEW-15	PHOTOCHEMISTRY - RISA
DER	AK 0104 010	NOEW-16	FUNDAMENTALS OF SEDIMENTATION
DER	AK 0104 010	NOEW-19	MODEING OF BUOYANT JETS
DER	AK 0104 010	NOEW-20	HEAT TRANSFER RESEARCH
DER	AK 0104 020	00105	COMPUTATIONAL MATHEMATICS
DER	AK 0104 020	00106	APPLIED ANALYSIS
DER	AK 0104 020	00107	DATA AND MODEL ANALYSIS
DER	AK 0104 032	00108	PHYS CHEM OF GEOTHERMAL SOLUTIONS
DER	AK 0104 032	00109	INTERACTIONS OF AQUEOUS MEDIA
DER	AK 0105 020	00112	TECH DEVEL OF ORDERED ALLOYS
DER	AK 0105 020	00113	NONDESTRUCTIVE TESTNG OF COMPOS
DER	AK 0105 020	00118	BES TECHNOLOGY CROSSCUT
DER	AK 0106 020	NOEW-17	MECH-BACTERIAL LEACHNG-METALS-ORES
DER	AK 0106 020	NOEW-18	MECH OF ATTACHMNT MICROORG-SOLID
DER	AK 0106 020	NOEW-21	MECH-METAL CONCENT-MICROB CELS
DER	AK 0181 034	4	FUEL FAB.-BSR-INVENTORY CHANGE
DER	AK 0181 035	5	FUEL FAB.-HFIR-INVENTORY CHANGE
DER	AK 0181 03X	6	FUEL FAB.-HPRR-INVENTORY CHANGE
DER	AK 0181 051	7	OTHER SPEC MATLS-INVENTORY CHANGE
DER	AK 0201 000	00114	NUC REMOTE MAINT TECH ASSESSMNT
ASCSA	BD 0101 010	00002	INDUSTRY DATA BOOK
ASCSA	BD 0101 020	00010	AGRICULTURAL & PROCESS HEAT
ASCSA	BD 0102 000	00401	PASSIVE SOLAR HEATING
ASCSA	BD 0201 000	00017	RESIDENT & COMMUN MODELING
ASCSA	BD 0202 000	00005	SOLAR TECH. TRANSFER PROGRAM
ASRA	BG 2002 000	ORN102	DEV PROC-REC UR WET PROC PHOS ACID
ASRA	BG 2002 000	ORN103	BIOPROCESS RECOV OF NUC FUEL VALUES
ASRA	BG 2002 000	ORN104	REC OF URANIUM FROM LOW-GRADE ORES
ASRA	BG 2030 000	ORN101	GRAND JUNCTION OFC INF SYSTEM
ASRA	BH 0103 000	00002	ENV RES ASSO WITH SMALL HYDRO TECH
ASET	C1 0701 020	00007	ELECTRIC ENERGY USE MANAGEMENT
ASET	C1 0701 030	00008	COMMUNICATION FIELD TESTING
ASET	C1 0701 040	NEW0626	POWER PLANT PERFORMACNE ANYL.
ASET	C1 0702 010	00002	2ND INTERNATIONAL SYMPOSIUM
ASET	C1 0702 010	00005	US/USSR COOPERATION
ASET	C1 0702 030	00004	HIGH VOLTAGE RESEARCH
ASET	C1 0702 030	00006	ENVIRONM EFFECTS OF DIELECTRICS
ASCSA	C3 0101 000	00002	ENERGY CONSERV HVAC SYST

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ASCSA	C3 0101 000	00008	INNOVATIVE STRUCTURES
ASCSA	C3 0101 000	00010	ENGINEERING/ECONOMIC MODELS
ASCSA	C3 0102 000	00009	BLDGS. ENERGY CONSUMPTION DATA
ASCSA	C3 0102 000	00014	BLDG THERMAL ENVELOP & INSUL MAT
ASCSA	C3 0102 000	NEW0621	BTESIM - IMPLEMENTATION
ASCSA	C3 0103 000	00018	COGENERATION DISTRICT HEATING SYS
ASCSA	C3 0103 013	00020	RESIDENTIAL ENERGY SERVICE PROGRAM
ASCSA	C3 0104 000	00001	HEAT PUMP RESEARCH & DEVEL.
ASCSA	C3 0104 000	00003	APPLIANCE MANAGEMENT
ASCSA	C3 0104 000	00011	HEAT PUMP MANAGEMENT
ASCSA	C3 0104 000	00017	THERMAL INSULATING MATERIALS
ASCSA	C3 0105 000	00005	MODELS OF ENERGY USE
ASCSA	C3 0105 000	NEW0054	INDUSTRIAL ENERGY POLICY STUDY
ASCSA	C3 0105 000	NEW0055	COGENERATION INFORMATION CENTER
ASCSA	C3 0106 000	00006	ANFLOW-MUNICIPAL
ASCSA	C4 1001 000	00009	MATLS FOR ENERGY RECUPERATORS
ASCSA	C4 1001 000	NEW0059	ANAEROBIC BIOREACTORS-INDUSTRIAL
ASCSA	C4 1001 000	NEW0060	RESOURCE RECOVERY FROM COAL
ASCSA	C4 2001 000	00002	INDUST CONSERV TECHNICAL SUPPORT
ASCSA	C4 3004 000	00001	ENERGY CONSER. DATA ANALYSIS
ASCSA	C5 0201 000	NEW0620	CHEMISTRY OF COAL SLURRIES
ASCSA	C5 0205 000	00001	TRANS. DATA ANYL. AND DATA BOOK
ASCSA	C5 0301 000	00002	TRANS. DATA ANYL. NONHIGHWAY SYS.
ASCSA	C5 0302 000	00003	TRANS. DATA ANYL. OF NEW CONCEPTS
ASCSA	C5 0303 000	00001	TRANSPORTATION ENERGY USE
ASCSA	C5 0601 020	00004	ELECTIC & HYBRID VEHICLES
ASET	C8 0301 021	00003	PHYS CHEMISTRY OF MOLTEN SALT BATT
ASET	C8 0302 011	00001	LOW TEMP THERMAL ENERGY STORAGE
ASET	C8 0302 024	NEW0063	CONCRETE STRUC FOR MAGN STORAGE
ASET	C8 0303 022	00002	CERAMIC RECUPERATORS
ASET	C8 0303 022	00011	THERMODYN ANALYSIS & CONV CYCLES
ASET	C8 0303 033	00005	PHYS CHEM OF FUEL CELL ELECTROLYTES
ERA	DK 0700 000	00001	EMERGENCY ENERGY CONSERVATION
ERA	DK 0801 000	00010	PWR SUPPLY PLANNING & APPL
ERA	DK 0801 000	00011	COGENERATION DISTRICT HEATING SYS
ERA	DK 0801 000	NEW0064	TIME OF DAY PRICING
ERA	DK 0801 000	NEW0626	POWER PLANT PERFORM. ANYL.
SPRO	EB 1001 000	00001	STRATEGIC PETROLEUM RESERVE PROJECT
EIA	FK 0101 010	00003	ENGINEERING/ECONOMIC MODELS
EIA	FK 0101 010	00004	HIGHWAY GASOLINE DEMAND MODEL
EIA	FK 0208 010	00002	END USE ENERGY CONSUMPT DATA BASE
EIA	FK 0301 000	00001	INFO DATA VALIDATION
ASEV	GK 0101 020	003258	DEVEL OF DECONT & DECOMM
ASEV	GK 0101 030	002975	POLICY ANALYSIS DIVISION
ASEV	GK 0101 040	002976	TECHNOLOGY ASSESSMENT DIVISION
ASEV	GK 0101 040	NOEW-03	SOUTHERN APPL REG REC TOUR & RE
ASEV	GK 0101 050	001725	FED ENV/SAFETY RESEARCH
ASEV	GK 0101 050	002224	ENVIRONMENTAL IMPACTS DIVISION

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ASEV	GK 0101 050	003278	NESS IMPACT ASSESSMENT PROJECT
ASEV	GK 0101 050	NOEW-04	MANAGEMENT OF NUMERIC DATA
ASEV	GK 0101 060	001684	REGIONAL ASSESSMENTS DIVISION
ASEV	GK 0101 071	800060	ASSESSM OF ECT FOR COAL CONV
ASEV	GK 0101 071	800158	HC & CO EFFLUENT CONTROL
ASEV	GK 0101 071	800300	GASIFIERS IN INDUSTRY-UMD
ASEV	GK 0101 071	800306	AN ENV ASSESSMENT OF COGENERATION
ASEV	GK 0101 071	800310	ELEVATED CO2 EFFECTS-TERR ECOSYST
ASEV	GK 0101 071	800361	H-COAL FIELD EVAL OF ECT
ASEV	GK 0101 071	800387	HAZARDOUS EVAL OF SOLID WASTES
ASEV	GK 0101 071	NOEW-05	RADIOL IMP OF COAL FUEL CYCLE
ASEV	GK 0101 071	NOEW-06	ALTERNATES TO AQUEOUS SCRUBBING
ASEV	GK 0101 071	NOEW-07	ASSM OF ECT FOR DISP OF SLUDGES
ASEV	GK 0101 075	800046	FULL SCALE IMPACT TESTNG-OBSO CASKS
ASEV	GK 0101 075	800133	TRANSP STAT DATA
ASEV	GK 0101 083	600097	EMERGENCY TECHNOLOGY
ASEV	GK 0102 011	000801	DOSIMETRY FOR HUMAN EXPOSURES
ASEV	GK 0102 011	001479	PUBLIC HEALTH & DEMOG STUDIES
ASEV	GK 0102 011	001480	ANAL & HEALTH EFF OF GAS & PRT EFF
ASEV	GK 0102 011	NOEW-09	ENERGY PROC GFF ON PHEROMONES
ASEV	GK 0102 021	000143	FISSION NEUTRONS & GAMMA RAY
ASEV	GK 0102 021	000146	DOSE RESPONSE RELATION IN CHEM
ASEV	GK 0102 021	000190	RADIATION IMMUNOLOGY
ASEV	GK 0102 021	001562	SOMATIC EFFECTS OF ENVIRONMENT
ASEV	GK 0102 021	002374	NUCLEIC ACID BIOCHEMISTRY
ASEV	GK 0102 021	002589	CARCINOGEN ACTIVITY IN HUMAN
ASEV	GK 0102 021	003148	SOL ST RADIOIMMUNOASSAY IN COC
ASEV	GK 0102 021	004086	RAPID ASSAYS FOR CARCINOGENIC
ASEV	GK 0102 021	NOEW-10	CHEM CARCINOGENS & UV RADN
ASEV	GK 0102 021	NOEW-11	METAL MUTAGENS & CARCS IN TRANSCRP
ASEV	GK 0102 021	NOEW-12	SUSCEPT TO CHEMICAL CARCINOGENS
ASEV	GK 0102 021	NOEW-13	GENETIC CONTROL OF ONCOGENIC POTENT
ASEV	GK 0102 021	NOEW-14	CARCINOGENIC INTERACTIONS
ASEV	GK 0102 021	NOEW-15	RADIOIMMUN OF DNA DAMAGE
ASEV	GK 0102 021	NOEW-29	CHEM EFFECT ON NUCLEIC ACIDS
ASEV	GK 0102 022	000173	MAMMALIAN BIOCHEMICAL GENETICS
ASEV	GK 0102 022	000174	MAMMALIAN GENETICS
ASEV	GK 0102 022	000181	MAMMALIAN CYTOGENETICS
ASEV	GK 0102 022	000184	EFFECTS & USES OF CHROM ABERR
ASEV	GK 0102 022	000237	MAMMALIAN TOXICOLOGY CELL GENETIC
ASEV	GK 0102 022	000287	MEDICAL & MOLECULAR GENETICS
ASEV	GK 0102 022	001569	COMPARATIVE MUTAGENESIS
ASEV	GK 0102 022	001570	MAMMALIAN CHEMICAL MUTAGENESIS
ASEV	GK 0102 022	002375	INTERMEDIARY METABOLISM OF MUT
ASEV	GK 0102 022	002527	GENETIC EFFECT OF PLUTONIUM
ASEV	GK 0102 022	002591	MECH OF MAMM MUTAG
ASEV	GK 0102 022	003152	GENETIC BASIS OF MUTAG/CARC
ASEV	GK 0102 022	NOEW-16	DEV OF SCRN METH-METAB-ACT MUT

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ASEV	GK 0102 022	NOEW-17	GENETIC DISSECT OF DNA REPAIR
ASEV	GK 0102 023	000159	BIOSTAT. & BIOMATH.
ASEV	GK 0102 023	000183	MAMMALIAN GAMETOGENESIS
ASEV	GK 0102 023	001702	POLLUTANTS IN CARDIOVASCULAR
ASEV	GK 0102 023	002362	CHEMICAL TOXICOLOGY
ASEV	GK 0102 023	002373	INITIATION OF TERATOGENESIS
ASEV	GK 0102 023	002578	BIOTOXICITY OF CHEMICALS
ASEV	GK 0102 023	004090	SELECTED TERATOGENIC TEST SYSTS
ASEV	GK 0102 023	NOEW-18	MECHANISM OF METAL TOXICITY
ASEV	GK 0102 031	000604	FUSION TECH: AQUATIC ENV CYC EFF
ASEV	GK 0102 031	000608	TRANS FATE & EFF OF EN TECHEM
ASEV	GK 0102 031	000681	ENV ELEM.-EFF OF URAN
ASEV	GK 0102 031	000690	ACTINIDES IN THE ENVIRON
ASEV	GK 0102 031	001624	ATMOS-TERR INTERACT OF ENTECH EM
ASEV	GK 0102 031	001677	PHY & CHEM CHAR OF PU IN COILS
ASEV	GK 0102 031	002382	FIELD SITE ENV RES-COAL CONV
ASEV	GK 0102 031	002528	RADIONUCL SRCS IN COASTAL ZONE
ASEV	GK 0102 031	003156	TC IN THE ENVIRONMENT
ASEV	GK 0102 031	003157	GASIFIERS IN INDUSTRY
ASEV	GK 0102 031	NOEW-19	COMP. ENV TOX COAL LIQ PRODUCTS
ASEV	GK 0102 032	000609	ECOLOGICAL PROCESSES-SOUTH RESERV
ASEV	GK 0102 032	000863	MECH IMPACTS OF ENTRAIN
ASEV	GK 0102 032	001693	ENV TRAN & EFF OF COAL CONV
ASEV	GK 0102 032	002201	NATL INV OF BIOL MONIT
ASEV	GK 0102 032	004081	ASSESS OF GAS FROM COAL CONV
ASEV	GK 0102 032	NOEW-20	EFF OF OZONATION OF COOLING WATERS
ASEV	GK 0102 032	NOEW-21	BIOCLIMATOLOGY OF ENERGY IMPACTS
ASEV	GK 0102 032	NOEW-22	MOD AIR POLLUT EFF ON VEGETATN
ASEV	GK 0102 032	NOEW-23	LIFE SCI FOSSIL ENERGY INFO
ASEV	GK 0102 033	001565	BIOENGINEERING RESEARCH
ASEV	GK 0102 033	001711	BIOCH TRTM-WST STRMS-COAL CONV
ASEV	GK 0102 033	002926	UTIL OF SULFUR-CYCLING MICROORG
ASEV	GK 0102 033	NOEW-24	CARBON TURNOVER FROM TERRESTRIAL
ASEV	GK 0102 033	NOEW-25	APPL OF REM SENSING ECOSYSTEMS
ASEV	GK 0102 034	000929	ENV RESEARCH PARK
ASEV	GK 0102 034	001670	NATIONAL CHLORINATION CONF
ASEV	GK 0102 034	002936	DEV OF GUIDELINES FOR MONIT
ASEV	GK 0102 034	002937	NERP-REF SYSTEM
ASEV	GK 0102 034	003235	RARE-II
ASEV	GK 0102 041	001602	CHEMISTRY IN THE ATMOSPHERE
ASEV	GK 0102 041	001603	PHYSIOCHEM PROP OF CHEM POLLUT
ASEV	GK 0102 041	001604	POLLUTION FORMATION & ATMOS CL
ASEV	GK 0102 041	001605	SURF INTERACT & ION PART ACCRET
ASEV	GK 0102 042	000720	LIQUID AND SUBMICRON PHYSICS
ASEV	GK 0102 042	000722	ATOMIC & MOLECULAR PHYSICS
ASEV	GK 0102 042	001478	STUDIES-PHYS PARAM-HEALTH PROT
ASEV	GK 0102 042	001706	MICRODOSIM
ASEV	GK 0102 043	000182	INSTR DEV FOR MONITORING MUT RATES

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ASEV	GK 0102 043	000714	HEALTH PHYS RESEARCH REACTOR
ASEV	GK 0102 043	000717	MED. PHYSICS & INT. DOSE
ASEV	GK 0102 043	000723	BASIC MEASUREMENT SCIENCE
ASEV	GK 0102 043	001606	CELL CYTOMETER-PERSONNEL MONITOR
ASEV	GK 0102 043	001607	MULTIDETECTOR SPECTROMETER SYST
ASEV	GK 0102 043	001608	RESONANCE IONIZATION SPECTROSCOPY
ASEV	GK 0102 043	001609	ENVIRONMENTAL MONITORING
ASEV	GK 0102 043	001707	NEW ENERGY SYSTEM DOSIMETRY
ASEV	GK 0102 043	001710	CHAR MEA & MONIT CHEM CHAR
ASEV	GK 0102 043	001722	CHAR MEA & MONIT FAC CHEM CONV
ASEV	GK 0102 043	002389	ULTRASEN POLL ANAL BY LASER FLUOR
ASEV	GK 0102 043	002391	ANAL APPLIC RESON SPECTRO
ASEV	GK 0102 043	002610	TRITIUM OXIDATION & EXCHANGE
ASEV	GK 0102 043	002613	AUTO ANAL WORKPLACE ENVIR
ASEV	GK 0102 043	003175	GASIFIERS IN INDUSTRY-UNIV OF MINN
ASEV	GK 0102 043	003176	GASIFIERS IN INDUST-PIKE CO.
ASEV	GK 0102 050	001669	CARBON DIOXIDE RES & ASSESS
ASEV	HK 0101 000	000151	REGULATION OF HEMATOPOIESIS
ASEV	HK 0101 000	000158	GROWTH AND REGENERATION
ASEV	HK 0101 000	000162	MECHANISMS OF RADIATION LETHAL
ASEV	HK 0101 000	000164	CARC SCREENING HUMAN CELL
ASEV	HK 0101 000	000165	NUCLEIC ACIDS IN PATHOGENESIS
ASEV	HK 0101 000	000167	THEORETICAL & APPLIED CRYOBI
ASEV	HK 0101 000	000169	ENZYME REGULATION
ASEV	HK 0101 000	000177	DROSOPHILA CYTOLOGY & GENETICS
ASEV	HK 0101 000	000178	YEAST MUTAGENESIS
ASEV	HK 0101 000	000179	MICROBIAL MUTAGENESIS AND CELL
ASEV	HK 0101 000	000184	EFFECTS & USES OF CHROM ABERR
ASEV	HK 0101 000	000233	PROTEIN SYNTHESIS:ABERRANT CO.
ASEV	HK 0101 000	000234	NUCLEOTIDE METABOLISM
ASEV	HK 0101 000	000279	APPLS OF BIO- AND CHEMILUMINES
ASEV	HK 0101 000	000282	PHOTOPHYSICS OF MACROMOLECULES
ASEV	HK 0101 000	000283	ENVIRONMENTAL INSULTS TO DNA
ASEV	HK 0101 000	000284	CHROMOSOME CHEMISTRY
ASEV	HK 0101 000	000286	STUDIES ON MUTATION INDUCTION
ASEV	HK 0101 000	000288	MOLECULAR GENETICS
ASEV	HK 0101 000	000607	DEV OF ECOL MODELING SYS
ASEV	HK 0101 000	000611	EASTERN DECIDUOUS FOREST BIOME
ASEV	HK 0101 000	000718	TRANSPORT & SURFACE PHYS
ASEV	HK 0101 000	000719	CHEMICAL PHYSICS STUDIES
ASEV	HK 0101 000	000720	LIQUID AND SUBMICRON PHYSICS
ASEV	HK 0101 000	000721	PHYS OF SOLIDS & MACROMOLECULES
ASEV	HK 0101 000	001471	X-RAY DIFFRACTION
ASEV	HK 0101 000	001472	PROTEIN CHEMISTRY
ASEV	HK 0101 000	001476	MOLECULAR ASPECTS OF RADIATION
ASEV	HK 0101 000	001558	BIOORGANIC CHEMISTRY & ENZYME
ASEV	HK 0101 000	001560	CHEMICAL EFFCTS ON THE IMMUNE
ASEV	HK 0101 000	001563	CARCINOGENS & GENE EXPRESSION

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ASEV	HK 0101 000	001603	PHYSIOCHEM PROP-CHEM POLLUTANTS
ASEV	HK 0101 000	001610	ENERGY PATHWAYS IN IRRAD GASES
ASEV	HK 0101 000	001699	GENE EXPRESSION IN CARCINOGENESIS
ASEV	HK 0101 000	001701	CARCINOGEN-CELL GENOME INTERAC
ASEV	HK 0101 000	002360	STUDIES ON TUMOR CELL IMMUNOL
ASEV	HK 0101 000	002368	REG OF RANE TRANSPORT
ASEV	HK 0101 000	002371	METABOLISM OF AROMATI AMINO
ASEV	HK 0101 000	003236	MECHANISMS OF DAMAGE AND REPAIR
ASEV	HK 0102 010	000982	HFIR & 86-INCH CYCL TECH SUPT
ASEV	HK 0102 010	001161	NUCL MED & RADIOISO TECH
ASEV	HK 0102 010	002283	DEV OF ISO SEPR FOR MED APPL
ASEV	HK 0102 010	004159	BIOMED COMPUTING TECH INFO CTR
ASEV	HK 0181 061	8	RADIOISOTOPES-INVENTORY CHANGE
ASEV	HK 0181 062	9	NON-EM STABLE ISO-INVENTORY CHANGE
DER	HK 0201 010	00001	HIGH ENERGY PHYSICS
DER	HK 0201 010	00002	HI-ENERGY ACCEL SHIELDING STUDIES
DER	HK 0301 010	00011	MESON PHYSICS
DER	HK 0302 010	00003	NUCL CHEM: NUCL REACT & STRUCTURE
DER	HK 0302 010	00012	HEAVY ION NUCLEAR PHYSICS
DER	HK 0302 020	00016	HEAVY ION LAB OPERATIONS
DER	HK 0302 020	00017	HIRF USER SUPPORT
DER	HK 0302 020	00018	HEAVY ION LABORATORY DEVEL
DER	HK 0303 000	00020	THEORETICAL PHYSICS
ASDP	JM 0301 364	ON5419A	233U STORAGE AND DISTRIBUTICN
ASDP	JM 0301 364	ON5519A	CON-ED U SOLIDIFICATION
ASDP	JM 0381 044	10	SRM-HEAVY WATER-INVENTORY CHANGE
ASDP	JM 0381 054	11	OSM-NEPTUNIUM-237-INVENTORY CHANGE
ASDP	JM 0401 000	OR04011	MICROSAM/RESIN-BEAD/MS SAFEGUARD
ASET	JM 0501 031	ONLWN01	LIQ & GASEOUS WASTE OPR
ASET	JM 0501 031	ONLWN03	GUNITE TANK SLUDGE DISPOSAL
ASET	JM 0501 031	ONLWN04	SOLID WASTE STORAGE MANAGEMENT
ASET	JM 0501 031	ONLWN07	WASTE VOLUME REDUCTION OPT
ASET	JM 0501 032	ONLWL14	DEV OF TECH FOR LAND BURIAL
ASET	JM 0501 032	ONLWN06	OPERATIONAL PLANNING & DEVEL/
ASET	JM 0501 033	ON9999A	UNAUTHORIZED
ASET	JM 0501 033	ONLWL15	RADIONUC MVMT FROM ORNL DISP AREAS
ASET	JM 0501 033	ONLWL16	RADIONUC SOIL MVMT CONT STUDIES
ASET	JM 0501 033	ONLWN05	HYDROFRACTURE MIX DEVELOPMENT
ASET	JM 0502 020	ONLWT06	TECH TO REDUCE WASTE GEN & VOL
ASET	JM 0502 030	ONLWL18	DEV METH REDUCE WASTE GEN
ASET	JM 0502 030	ONLWL21	TESTING & DEMON ALT DISP METHODS
ASET	JM 0502 040	ONLWAXX	TRITIUM CONCENT BY BIPOLAR ELECT
ASET	JM 0502 055	ONLWX01	INTEGRATED NUC WASTE MGT ANAL
ASET	JM 0505 000	ONLWD01	D&D OF FAC AFTER OCT 1976
DER	KK 1001 000	00001	REGIONAL ENERGY ANALYSIS
DER	KK 1001 000	00002	NESS IMPACT ASSESSMENT
DER	KK 1001 000	00003	MODELS OF ENERGY CONSERV
DER	KK 1001 000	NEW0068	IMP ASSESSM FOR NEP PLANNING
DER	KN 0202 040	00007	UNIVERSITY RELATIONS