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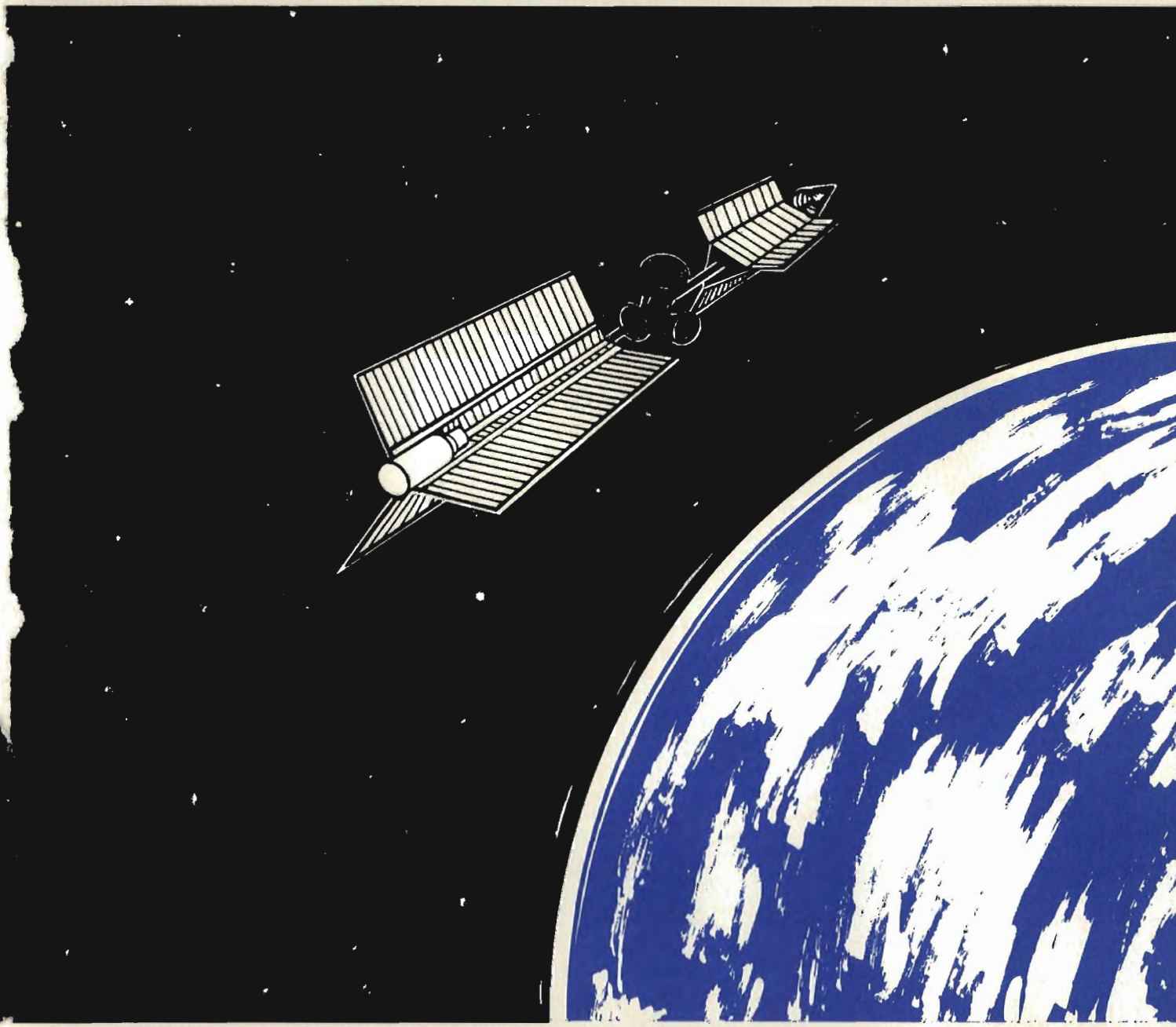
Institutional Plan FY 1985 - FY 1990



Oak Ridge National Laboratory

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Cover: *ORNL is seeking missions in several areas of space nuclear power, including space nuclear reactors, energy storage systems, and directed-beam weapons. This artist's conception shows a possible configuration for the reactor and energy storage system.* Design by A. D. Richardson.

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OAK RIDGE NATIONAL LABORATORY INSTITUTIONAL PLAN FY 1985–FY 1990

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ACRONYMS

ADP	automated data processing
ADPE	automated data processing equipment
AEC	Atomic Energy Commission
AEOD	analysis and evaluation of operational data
AFESC	Air Force Engineering and Services Center
AID	Agency for International Development
AIM	Accelerator Improvement and Modification
AIP	Accelerator Improvement Project
AMSL	Analytical Mass Spectrometry Laboratory
ANL	Argonne National Laboratory
ARIM	Accelerator and Reactor Improvement and Modification
ASCE	Assistant Secretary for Conservation and Renewable Energy
ASDP	Assistant Secretary for Defense Programs
ASFE	Assistant Secretary for Fossil Energy
ASIAEE	Assistant Secretary for International Affairs and Energy Emergencies
ASMA	Assistant Secretary for Management and Administration
ASNE	Assistant Secretary for Nuclear Energy
ASPSE	Assistant Secretary for Policy, Safety, and Environment
ATF	Advanced Toroidal Facility
BA	budget authorization
BER	Building Equipment Research
BNL	Brookhaven National Laboratory
BO	budget obligation
BRET	Breeder Reprocessing Engineering Test
BRF	Bioprocessing Research Facility
BTESM	Building Thermal Envelope Systems and Materials
BWR	boiling-water reactor
CAD	computer-aided design
CAM	computer-aided manufacturing
CBCF	carbon-bonded carbon fiber
CDEP	Cooperative Developmental Program
CDIC	Carbon Dioxide Information Center
CFRP	Consolidated Fuel Reprocessing Program
CRBRP	Clinch River Breeder Reactor Project
CTD	Computing and Telecommunications Division
DHHS	Department of Health and Human Services
DOD	Department of Defense

DOE	Department of Energy
DOI	Department of the Interior
DOJ	Department of Justice
DOT	Department of Transportation
EBS	Elmo Bumpy Square
EBT	Elmo Bumpy Torus
ECUT	Energy Conversion and Utilization Technologies
EIA	Energy Information Administration
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
ERAB	Energy Research Advisory Board
ERIP	Energy Related Inventions Program
ETP	Emergency Technology Program
FDA	Food and Drug Administration
FEDC	Fusion Energy Design Center
FEMA	Federal Emergency Management Agency
FERC	Federal Regulatory Commission
FFTF	Fast Flux Test Facility
FMEF	Full Materials Examination Facility
FMIT	Fusion Materials Irradiation Test
FTE	full-time equivalent
GAT	GA Technologies
GPE	General Purpose Equipment
GPP	General Plant Project
HASRD	Health and Safety Research Division
HBCU	historically black colleges and universities
HCDWMP	Hazardous Chemical Defense Waste Management Program
HCW	hazardous chemical waste
HEDL	Hanford Engineering Development Laboratory
HFIR	High Flux Isotope Reactor
HHIRF	Holifield Heavy Ion Research Facility
HPRR	Health Physics Research Reactor
HTGR	high-temperature gas-cooled reactor
HTML	High Temperature Materials Laboratory
IAEA	International Atomic Energy Agency
IDB	Integrated Data Base
IET	Integrated Equipment Test
INS	Immigration and Naturalization Service
INTOR	International Tokamak Reactor
IRI	Industrial Research Institute
ISB-X	Impurity Studies Tokamak Experiment
JAERI	Japanese Atomic Energy Research Institute
JET	Joint European Torus
LLNL	Lawrence Livermore National Laboratory

LMR	liquid-metal reactor
LWR	light-water reactor
MFTF	Mirror Fusion Test Facility
MGPF	Multiprogram General Purpose Facilities
MHD	magnetohydrodynamics
MHTR	modular high-temperature reactor
MPRE	Medium Power Reactor Experiment
NASA	National Aeronautics and Space Administration
NCI	National Cancer Institute
NEPA	National Environmental Protection Act
NLM	National Library of Medicine
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
NSF	National Science Foundation
NTP	National Toxicology Program
OCRWM	Office of Civilian Radioactive Waste Management
OEC	Office of Environmental Compliance
OEP	Office of Electric Power
OER	Office of Energy Research
OHER	Office of Health and Environmental Research
ORAU	Oak Ridge Associated Universities
ORELA	Oak Ridge Electron Linear Accelerator
ORGDP	Oak Ridge Gaseous Diffusion Plant
ORNL	Oak Ridge National Laboratory
ORO	Oak Ridge Operations
ORTA	Office of Research and Technology Applications
PNL	Pacific Northwest Laboratory
PPPL	Princeton Plasma Physics Laboratory
RASLA	Remedial Action Survey and Certification
RCS	Residential Conservation Service
RIMS	Resonance Ionization Mass Spectrometry
SCSS	Sequence Coding and Search System
SDP	Site Development Plan
SFC	Synthetic Fuels Corporation
SNL	Sandia National Laboratory
TEC	total estimated cost
TFCX	Toroidal Fusion Core Experiment
TFTR	Tokamak Fusion Test Reactor
THORS	Thermal Hydraulic Out-of-Reactor Safety
TRU	transuranium
TVA	Tennessee Valley Authority
UMTRAP	Uranium Mill Tailings Remedial Action Program
WFO	Work for Others

Director's Statement

DIRECTOR'S STATEMENT

The *FY 1985–FY 1990 Institutional Plan* will be the first to reflect some important recent changes for the Oak Ridge National Laboratory (ORNL). On April 1, 1984, Martin Marietta Energy Systems, Inc., assumed responsibility for operation of ORNL and its three sister Department of Energy (DOE) facilities. The transition from Union Carbide Corporation, contractor for 38 years, to Martin Marietta Corporation has been a smooth one largely because of the planning and work that went into it. Disruption has been minimal, which is a credit both to DOE local and Headquarters staff for the planning and selection process.

The arrival of Martin Marietta Corporation coincides nicely with the fruition of movements set afoot in Washington following completion of the three panel studies of the multiprogram laboratories. The result is that the new contract has fewer restrictions, so we can do a better job for DOE. We are particularly pleased with some of the measures taken to allow more flexibility commensurate with greater accountability. Also this year for the first time, ORNL is conducting a set of projects selected as part of the expanded Exploratory Studies Program, which was established as a result of several panels' recommendations. Some of those projects appear in this Institutional Plan as New Initiatives because we have judged them to be candidates worthy of efforts to establish permanent new program directions. This newly increased flexibility is much appreciated and will be important in allowing the Laboratory to pursue important and innovative ideas. We are, in fact, proposing at least two major New Initiatives, which we hope will command serious attention.

Not everything in ORNL's outlook on the future is positive. For some time now, the DOE facilities in Oak Ridge, primarily at Y-12 and secondarily X-10, have been under a tremendous amount of scrutiny because of their perceived and potential environmental effects. A long-range plan to accomplish the necessary work has been developed, and we will need continuing support for some time to come if ORNL is to address its problems in a permanent way. It is essential that Headquarters continue to allocate resources for a sustained effort in this area.

Another serious problem is the uncertainty that has developed following the demise of the Clinch River Breeder Reactor Project (CRBRP). Although DOE is working toward developing new program plans, at the moment no clear direction exists for the future of the breeder program itself or of related programs such as Consolidated Fuel Reprocessing. ORNL is concerned that the cancellation of the CRBRP will have a domino effect on many other important nuclear research and development (R&D) efforts and engender one more major setback to nuclear energy in the United States. Our planning and initiatives are directed to address these concerns.

Continued contraction of the biological sciences at ORNL and in DOE has caused multiple adjustments and readjustments of our missions in this area. Consolidation of organizations, buildings, and facilities has taken much time and effort because the staff has been reduced by a factor of 2. The much smaller staff has left us facing problems of critical size to address the large tasks for DOE.

Major pending decisions concerning fusion experiments, for example, the ignited-plasma experiment, will strongly involve ORNL either as a strong supporter, developer, and participant if the

ignited-plasma experiment is built elsewhere or as a direct participant in the Martin Marietta, Energy Systems, Inc., organization responsible for the project if it is built in Oak Ridge. Either will present us with an exciting future. Efforts to reduce the federal budget deficit are anticipated to impact strongly the R&D budgets and could offset dramatically these projections.

The overall energy picture in the United States is changing from a glut to a normal growth rate. In fact, as the United States recovers from its prolonged recession, electrical growth rates have been enormous, 10 to 14%, causing renewed concern for adequacy of supplies. Current global environmental issues—carbon dioxide, acid deposition, and other atmospheric phenomena—call into serious question the simple extension of past practices into the future. All these issues coupled with the volatility of the Middle East and the worldwide economic recovery indicate that energy will soon have a higher profile again and that energy R&D will be viewed with a new urgency. The 1987–1989 time period is likely to be characterized as one of increased activity, with questions only about why we were not *doing* these things in 1983, 1984, and 1985 when we had a breathing spell.

Herman Postma

Herman, Postma, Director

Laboratory Missions

LABORATORY MISSIONS

The primary mission of the Oak Ridge National Laboratory (ORNL) is to carry out applied research and engineering in fusion, fission, and other energy technologies, and scientific research in basic physical and life sciences. ORNL designs and provides research facilities for the benefit of members of the scientific and technical community and maintains close interaction with scientific personnel in universities and industry. An important part of ORNL's mission is the manufacture and sale of radioactive and stable isotopes that are not available from the private sector.

To fulfill its mission, ORNL focuses its scientific and technical efforts on (1) magnetic fusion, with emphasis on applied plasma physics, experimental and design studies of confinement configurations, development of plasma heating and fueling systems, development of prototype superconducting confinement magnets, and testing of candidate first-wall and blanket materials; (2) nuclear fission, focused on development of nuclear fuel reprocessing, materials testing and development for high-temperature gas-cooled and advanced converter reactors, and technologies for managing nuclear waste; (3) biological and environmental research, with emphasis on interaction of energy-related physical and chemical agents with living organisms; (4) conservation and renewable energy, with emphasis on generic research for high-temperature materials, power systems, biomass production, energy storage, and technology development for buildings and industry; (5) fossil energy, focused on development of materials for fossil fuel applications and on health and environmental effects of coal conversion systems; and (6) basic research in physical sciences, with emphasis in materials research on radiation effects, neutron scattering, and photovoltaic conversion; in chemical sciences on aqueous solutions; and in nuclear physics on heavy-ion reactions.

New Initiatives

NEW INITIATIVES

New Concepts in Research Reactors: HFIR-II

A project is proposed to design and construct the world's best research reactor at Oak Ridge National Laboratory (ORNL) as a replacement for the High Flux Isotope Reactor (HFIR). The project has three major goals: (1) to provide unsurpassed neutron-scattering facilities for the growing community of scientists engaged in using the neutron as a probe to study the structure and dynamics of materials; (2) to improve our isotope production capabilities; (3) and to provide improved, flexible facilities for materials irradiation studies.

Neutron scattering, which was born as a by-product of the U.S. investment in research reactors, has provided unique and fundamentally important information for a wide variety of scientific disciplines: condensed matter physics, chemistry, biology, materials science, and polymer science. In recent years, because of a much larger investment in funds and personnel by the West Europeans, the United States has lost the role of world leadership in neutron scattering. It is time to leap ahead in this field by replacing some of our aging neutron sources currently in use by new, more powerful facilities. The benefits to neutron scattering will come in part from a higher thermal flux and in part from the opportunity to build better beam tubes, to add cold neutron sources, and to build more and improved scattering instruments. By combining higher source strength and improved beam tube design, we plan to achieve an order of magnitude increase in the number of neutrons incident on the sample for many experiments. The planned cold sources and beam guides should provide cold neutron beams six times as intense as those at the Institute Laue-Langevin.

The HFIR was designed to produce a very high flux of thermal neutrons in the central flux-trap region for the production of transuranium (TRU) elements. The chemistry of these elements and their compounds constitutes one of the most challenging and significant frontiers of the chemical sciences. We now know that the production of certain important isotopes, such as ^{252}Cf and ^{254}Es, would be greatly enhanced by providing a neutron spectrum that has more epithermal neutrons than are available in the HFIR. The new design will provide target positions in various locations within the central region and the outer reflector to allow isotope production with differing neutron spectra. The epithermal flux is expected to be at least a factor of 3 higher than in the HFIR.

The most difficult materials problem the United States faces is in the construction of fusion reactors. A new research reactor with improved irradiation facilities and abundant fast neutrons would be a major resource for the fusion materials program. The demise of the Fusion Materials Irradiation Tests (FMITs) makes the subject have even greater importance. By providing target positions close to the reactor core and providing for control and monitoring of the sample environment, we will greatly improve our capabilities for irradiation effects experiments.

Neutron scattering is a field ideally suited for the establishment of a strong user program at a national laboratory. It requires a large, expensive facility and has important applications in many

scientific disciplines. The total number of neutron scattering users at all U.S. facilities has increased from about 250 to over 500 in the last 5 years. American industry is now becoming aware of the value of neutron scattering in understanding the behavior of new materials. In the past 3 years, 23 scientists from companies such as Eastman Kodak, Firestone, E. I. Du Pont de Nemours, Exxon, IBM, Ford, and Chevron have used the neutron-scattering facilities at the HFIR. The proposed reactor would be operated as a national user facility, open to any research proposal of high scientific merit.

Preconceptual design studies are already in progress. The proposed reactor will be designed for approximately 200 MW thermal power, with a large deuterium oxide (D_2O) reflector to accommodate many experimental facilities. The fuel will probably have cylindrical symmetry, with the exact geometry selected to maximize the utilization of the neutron flux. Preliminary calculations indicate that a peak thermal flux in the reflector of about 5×10^{15} $n \cdot cm^2/s$ can be achieved with only modest advances in current technology. To provide neutrons over a wide range of energies for scattering experiments, two cold sources and a hot source will be installed in the D_2O reflector. Totally reflecting guides will conduct the cold neutrons to a large guide hall adjacent to the reactor building. Sufficient beam tubes and beam guides will be provided to allow the installation of about 30 neutron spectrometers of various types. The mix of spectrometer types will be decided after consultation with prospective users in the fields of solid state physics, metallurgy, biology, chemistry, polymer science, and nuclear physics.

Cost summary: HFIR-II
($ in millions)

	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990
R&D related to construction	6.2	14.6	11.6		
Procurement and construction				50.0	90.0

Strategic National Defense System

ORNL has extensive experience in many of the technology areas closely related to some of the mission requirements being considered in the Strategic Defense Initiative of the Department of Defense (DOD). For example, ORNL has prepared a preliminary design of a space-based, multi-megawatt power system with an integrated flywheel storage system capable of delivering 1×10^4 MW/s of pulsed energy. The power and energy storage systems are designed for delivery to orbit as two space shuttle payloads. Also, neutral-beam research at ORNL has resulted in the development of negative particle sources having extremely low beam divergence corresponding to an ion temperature of 0.7 eV. As such, these sources can help provide the high-intensity, tightly collimated beam needed for directed energy applications.

The work proposed in this initiative will utilize and build on technologies and experience well established at ORNL. Relevant space reactor background at ORNL includes the Medium Power Reactor Experiment (MPRE) program conducted in the 1960s and the extensive high-temperature, liquid-metal-cooled component and system development activities. The technology base established in the recent Mechanical Energy Storage program and by other major technology development

programs being carried out at other installations in the Oak Ridge area provides strong background for the proposed energy storage system. The beam technology required is supported by a large body of ion source development work carried out over the last two decades.

ORNL's mission, in cooperation with other Department of Energy (DOE) and DOD laboratories and industry, will be to evaluate and develop the system concept, plan the technology development program, implement those parts appropriate to Oak Ridge expertise, and coordinate the remaining work with other organizations. Studies related to scale-up feasibility, systems integration, and subsystem design will also be involved. Mission-driven performance criteria will be established for each system component, and development programs focused to meet these criteria will be planned and implemented. These activities not only will involve major efforts at ORNL and in the Oak Ridge complex but also will include substantial subcontract or cooperative activities at other locations with complementary expertise.

Some examples of technology areas to be pursued are (1) for reactors—core performance, two-phase flow, materials, shielding, and instrumentation and controls; (2) for energy storage—flywheel fabrication and testing, power conditioning, and system reliability; and (3) for beam systems—ion source design, fabrication and performance testing, radio frequency (rf) quadrupole, linear-accelerator, and beam-steering neutralization studies.

New funding is expected to be modest but adequate to start the program in FY 1985. Significant growth will be necessary in subsequent years to meet the mission schedules and objectives. Major activities both in-house and through subcontracting will be involved. Capital equipment will be required to support fuels and materials test facilities, thermal hydraulic and two-phase flow loops, and beam test facilities.

Resource projections: Strategic National Defense System
(in millions)

	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990
Total operating, $	3.0	17.0	28.0	35.0	35.0	35.0
Subcontracts, $	1.0	6.0	9.0	12.0	12.0	12.0
Capital equipment, $	0.5	2.5	5.0	5.0	5.0	5.0
Direct personnel, FTE	20	100	170	200	200	200

Expanded Role for ORNL in an Ignited-Plasma Fusion Experiment

A tokamak ignition device is being considered by the DOE Office of Fusion Energy as the next major focus for the Magnetic Fusion Program. The main goal of this device, which has also been called a burning core experiment, is the production of ignited, long-pulse, deuterium-tritium–burning plasmas. In preconceptual design studies, two main configurations are being considered. The first of these has superconducting coils with a major radius of about 3.5 m, a plasma current of 7–11 MA, a toroidal magnetic field of 5 T, and at a minimum 2×10^5 burn-seconds. The maximum tritium inventory will be <200 g, and the vulnerable tritium inventory will be <18 g. Facility requirements include the need to handle tritium, to provide an exclusion zone for the site, and to provide up to a few hundred megawatts of electrical power and an average cooling of ~50 MW(th) for the basic machine. Possible upgrades to greater performance are being studied.

The second configuration uses water-cooled copper coils, and studies are under way to identify the lowest cost, smallest ignition machine through this route.

There are two complementary roles for ORNL in an ignited-plasma experiment. The first of these, discussed below, is independent of the siting of the device. The second involves the possibility of the Oak Ridge area as a site.

ORNL and the Engineering and Computing and Telecommunications divisions are actively involved in the project to study specific machine concepts, both through the Fusion Engineering Design Center (FEDC) and through the Fusion Energy Division. The FEDC gives support in plasma engineering, engineering, and systems integration to Princeton Plasma Physics Laboratory (PPPL). ORNL through the Fusion Energy Division is responsible for coordinating the research and development (R&D) needs assessment for the project team. Plans are being formulated to expand the role of ORNL in the project and in the overall program. This may be accomplished through increased support of the FEDC; independent studies, in cooperation with PPPL, of critical issues such as noninductive current drive and particle and impurity control; increased effort on one of the contending designs; and increased development and technology support. All of these efforts should enhance the role of the FEDC and ORNL in building the project if it is authorized. The budget projections shown assume continuation of support for the FEDC at approximately the FY 1984 level of $5 million per year.

In the early phase of the program, it was assumed that an ignited-plasma device would be built at PPPL as a continuation of the Tokamak Fusion Test Reactor (TFTR) program and because using TFTR facilities would minimize the cost. This assumption has been questioned, notably by the Energy Research Advisory Board (ERAB) in a recent (1983) report. Questions have been raised about limitations the PPPL site might impose on the larger device and its upgrades, and the likelihood that subsequent more powerful devices could not be sited there. While the TFTR site may be the logical choice for a small ignition device, the Oak Ridge Reservation offers superior capability for the larger experiment and future fusion projects. A siting document has been drafted that outlines the capabilities of ORNL, Oak Ridge Gaseous Diffusion Plant (ORGDP), and the facilities available for the Poplar Creek Site. This site is adjacent to ORGDP and has available over 1000 MW(e) of electrical switchyards and hundreds of megawatts (thermal) of cooling. It is near available office, storage, and support facilities including a large machine shop. The site is compatible with many times the tritium requirements of an ignited-plasma experiment, and it is readily accessible by road, rail, and river. If locations other than Princeton are considered, ORNL proposes to extend and complete these preliminary studies and to promote actively the Oak Ridge area as the site for the experiment.

The cost of the larger device and its supporting activities is of the order of $1 billion, and when completed it would entail upward of $100 million in annual operating costs. The project would be a collaborative venture involving industry, universities, national laboratories, and possibly other countries. Because of its size and the need for fully integrated project management, a separate organization, parallel to ORNL, would be formed as a part of Martin Marietta Energy Systems, Inc.

Budget projections: ORNL support to an Ignited-Plasma Fusion Experiment[a]
($ in millions)

FY 1984	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990
5.0	5.0	5.0	5.0	9.0	14.0	24.0

[a]Does not presume project siting in Oak Ridge.

Advanced Reactor Program

The cancellation of the Clinch River Breeder Reactor Project (CRBRP) forces the United States into a reconsideration of the course of federally supported reactor development and demonstration. The future of the breeder must be considered in context with the problems in the commercial reactor industry and the recent increase in interest in small reactors, demonstrably safe reactors, advanced convertor reactors, and reactors for military applications. Having both breadth and depth in reactor R&D and broad multidisciplinary capabilities, ORNL is superbly equipped to provide both leadership and support to DOE in the evolving reactor program.

The first step in the restructuring of the U.S. reactor programs is the definition of goals and objectives. The next step is the examination of specific and generic technological issues and options for the future of nuclear power. ORNL has instituted a discretionary-funded effort to initiate work in these first two steps. The study effort includes broad contacts with industry and government and a senior advisory committee. This work will serve well as a planning and evaluation service to the national program, and DOE is expected to provide funding to continue it.

DOE has requested industry proposals for innovative reactor concepts and is expecting many responses. ORNL will assist DOE in evaluating the technical and institutional issues from the candidate proposals. The current base-technology breeder program at ORNL will be restructured to provide appropriate base technology to address the key technical issues for new liquid-metal-cooled reactor concepts and possibly for other innovative designs, such as the modular gas-cooled reactor. Design-specific analyses and experiments will be carried out in all of the base technology areas currently addressed in the ORNL program: materials and structures, safety, shielding, and instrumentation and control.

The materials and structures program will contribute in the following important areas: (1) removal of anticipated licensing impediments through confirmatory structural design testing programs, generation of mechanical properties for castings and weldments, evaluation of irradiation effects, in-service inspection of stainless steel weldments, and high-temperature fracture mechanics; (2) qualification of modified 9 Cr–1 Mo steel as the universal liquid-metal reactor (LMR) system alloy with the best possibility of eliminating not only the transition joints but also the intermediate heat transport system; (3) development of improved inelastic design guidelines and procedures; (4) reform of design codes and standards and engineering practices leading to simpler, less conservative rules and simplified design analysis methods; and (5) incorporation of information from foreign programs through exchange and collaboration.

In the area of safety, increased emphasis will be placed on experimental validation of intrinsic shutdown heat removal for specific innovative designs. The shielding effort will concentrate on providing design-specific shielding analysis and in qualifying advanced shielding materials such as boron carbide and boronated graphites. Advanced instrument components, methods, and systems will be developed and qualified for commercial innovative plant design, including automated control system designs. Much of the information developed in this effort will be applicable to gas-cooled reactor designs as well as to liquid-metal systems.

In summary, ORNL will assume a lead support role to DOE in the development and evaluation of advanced reactor concepts and designs. This will include base technology support, system studies, design analysis, and evaluation. The overall objective of this effort is (1) economic competitiveness with conventional light-water reactors (LWRs) and fossil plants, (2) capability of being fabricated and constructed within five years, (3) substantially reduced complexity compared with conventional LWRs, (4) environmental acceptability, and (5) a breeder option with an acceptable growth.

Resource projections: advanced breeder reactor program
($ in millions)

	FY 1984	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989
Total operating, $	9.0	10.0	12.0	12.0	12.0	12.0
Direct personnel, FTE	75	80	90	90	90	90

Protein Engineering/Bioprocess R&D

Methodology now exists to alter any amino acid residue of a protein by site-directed mutagenesis of its gene. We plan to combine our expertise in protein biochemistry and molecular genetics to establish a new research initiative in protein engineering/bioprocessing. This initiative will be linked to other important ORNL research activities, such as X-ray diffraction methods, determining detailed protein structural information, position-sensitive detectors for recording diffraction patterns, gene sequencing, gene cloning, protein chemistry, and three-dimensional computer graphics. By using the sophisticated techniques of molecular biology, we plan to directly modify genes to alter the structure of proteins in a predictable manner, thereby altering functional properties. We would thus build new gene products (proteins) with desired properties, for example, enzymes that would be controlled in turnover number, thermostability, stability and/or activity in solvents other than water, substrate specificity, and pH optima. These modified proteins would be extremely helpful in various bioprocess schemes.

The techniques for enzyme engineering and recombinant deoxyribonucleic acid (DNA) have opened up new vistas for innovative biotechnology. However, most bioprocessing systems are still based on the technology of many years ago. We propose that a concerted effort be initiated to develop a new, advanced family of bioreactor systems that can take advantage of the results of applied biological research as well as modern engineering practices. Such processing systems would have applications in the conversion of biomass to useful fuels and chemicals for environmental control technology. We will also review the need for associated modern instrumentation that could be useful to bioprocess activities.

The goal will be to develop bioreactor concepts that are at least a factor of 10 more efficient than those used in current industrial practice. The final developments will include the use of multistage columnar systems that operate on a continuous basis and that use high concentrations of immobilized biocatalysts.

These activities will supplement ongoing R&D activities associated with the ORNL Bioprocessing Research Facility user resource.

Resource projections: protein engineering/bioprocess research and development
(in millions)

	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990
Total operating, $	2.5	5.0	6.0	7.5	7.6	7.8
Capital equipment, $	2.0	0.5	0.6	0.8	0.8	0.8
Direct personnel, FTE	21	40	50	60	60	62

Overview of Laboratory Activities

OVERVIEW OF LABORATORY ACTIVITIES

Since 1979, the Department of Energy's (DOE's) Office of Energy Research (OER) has been ORNL's largest single sponsor. Based on total Laboratory direct personnel, OER has funded roughly 45% of our total effort. The Director of OER also has overall responsibility for the Laboratory. The Assistant Secretary for Nuclear Energy (ASNE), the Assistant Secretary for Programs (ASDP), and the Assistant Secretary for Conservation and Renewable Energy (ASCE) have also supported large efforts at the Laboratory over the past several years. Figure 1 shows trends in Laboratory effort by major sponsor. In general, the projections contained in this plan are for little variation in relative proportion of overall effort devoted to the various DOE sponsors with the exception of a major increase in planned effort for the Office of Civilian Radioactive Waste Management (OCRWM). (See discussion of Program DB.) This work is included in the "Other DOE" category of Fig. 1. A slight shift in Work for Others (WFO) sponsorship is also expected, with the relative share of effort for the Nuclear Regulatory Commission (NRC) decreasing slightly (from 9 to 7%) over the planning period. This shift is balanced by an increase in effort for various

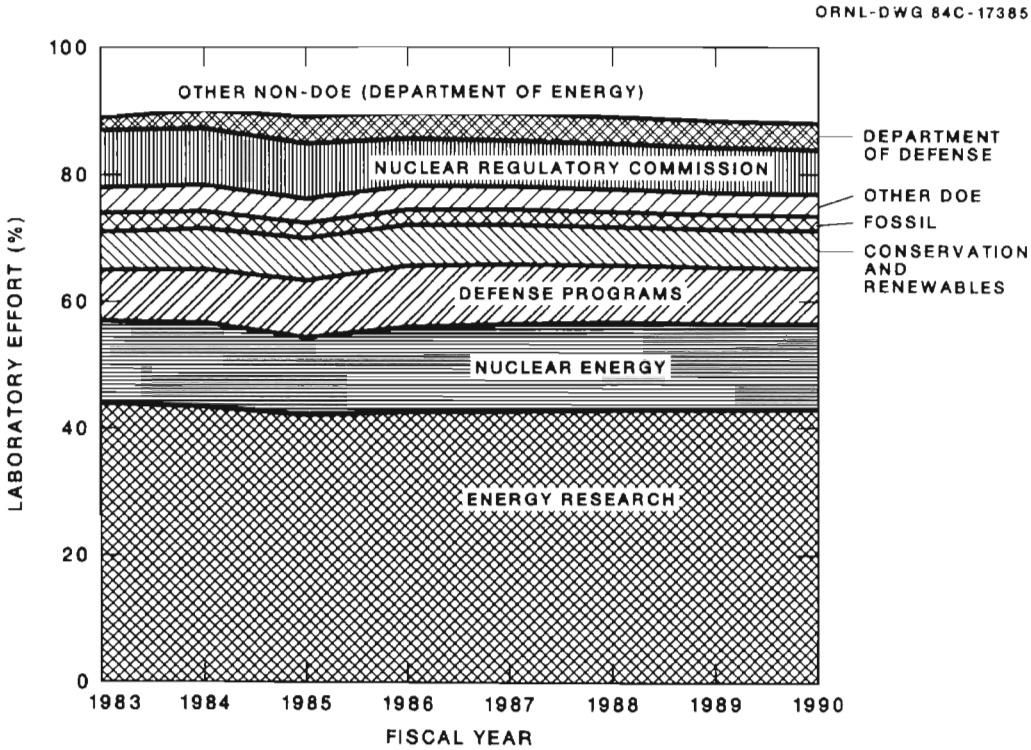


Fig. 1. Trends in Laboratory effort. Percentage is based on total Laboratory direct personnel.

branches of the Department of Defense (DOD), which is projected to increase from an FY 1983 level of 2% to roughly 4% in FY 1990. Figure 2 shows the current (FY 1984) level of effort for the major sponsors. Figure 3 gives information on the distribution of WFO funding and personnel. Although the predominance of NRC is decreasing, this agency still funds 39% of ORNL WFO tasks.

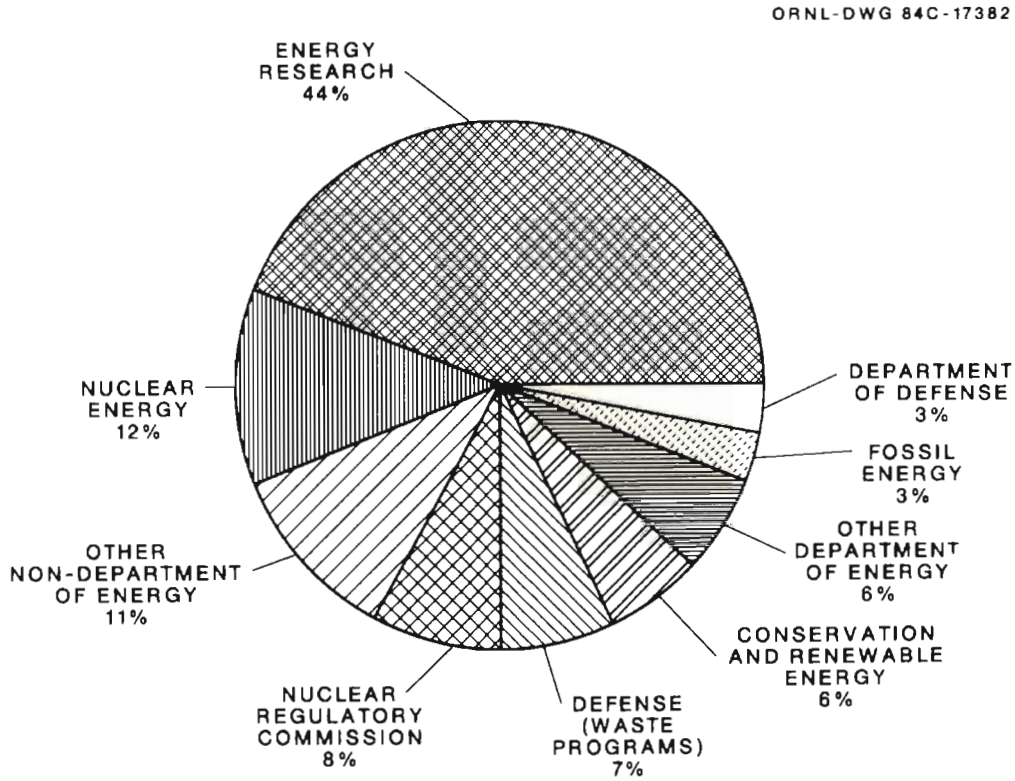


Fig. 2. FY 1984 effort for major sponsors (1993 direct full-time equivalents).

Figure 4 shows the Laboratory's funding level over time. Year-to-year fluctuations in total projected funding level are predominantly attributable to large increases in work for OCRWM and to major items of proposed construction, such as High Flux Isotope Reactor–II (HFIR-II) and the Toxic Substances Laboratory and Animal Facility. Proposed construction projects and associated costs are further discussed under New Initiatives, Scientific and Technical Programs, and Site and Facilities.

The trend in personnel levels (Fig. 5) is for modest increases in total personnel. If programmatic effort is distributed as projected in this plan, the number of total personnel projected for FY 1990 is near the FY 1981 level. Thus the Laboratory's overall plan is for a generally stable future, with growth in selected areas offset by decreasing emphasis in others.*

*See appendix for further data on funding and personnel levels.

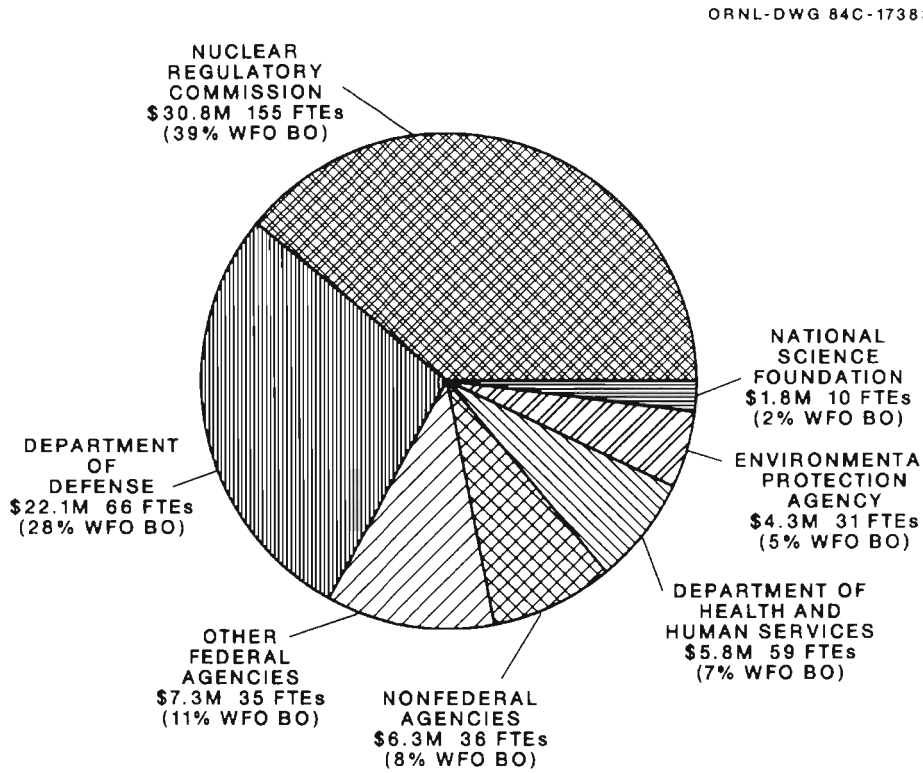


Fig. 3. FY 1984 effort in Work for Others (WFO): $78.4 million (BO) and 392 full-time equivalents (FTEs).

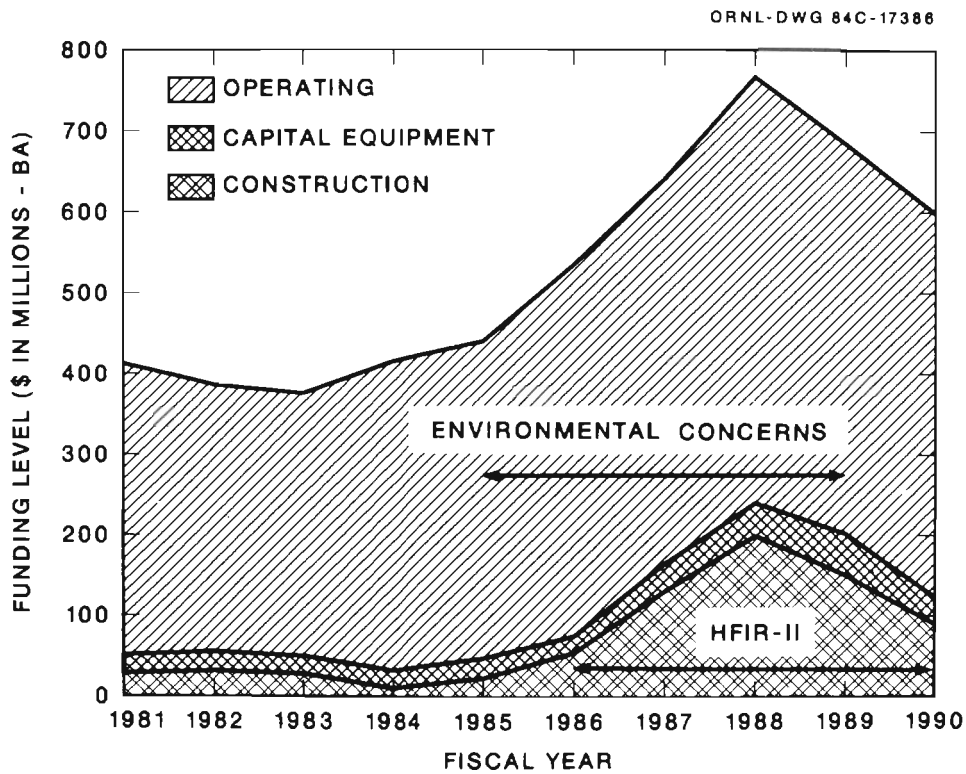


Fig. 4. Trends in funding level. Figures from 1985 to 1990 are projections.

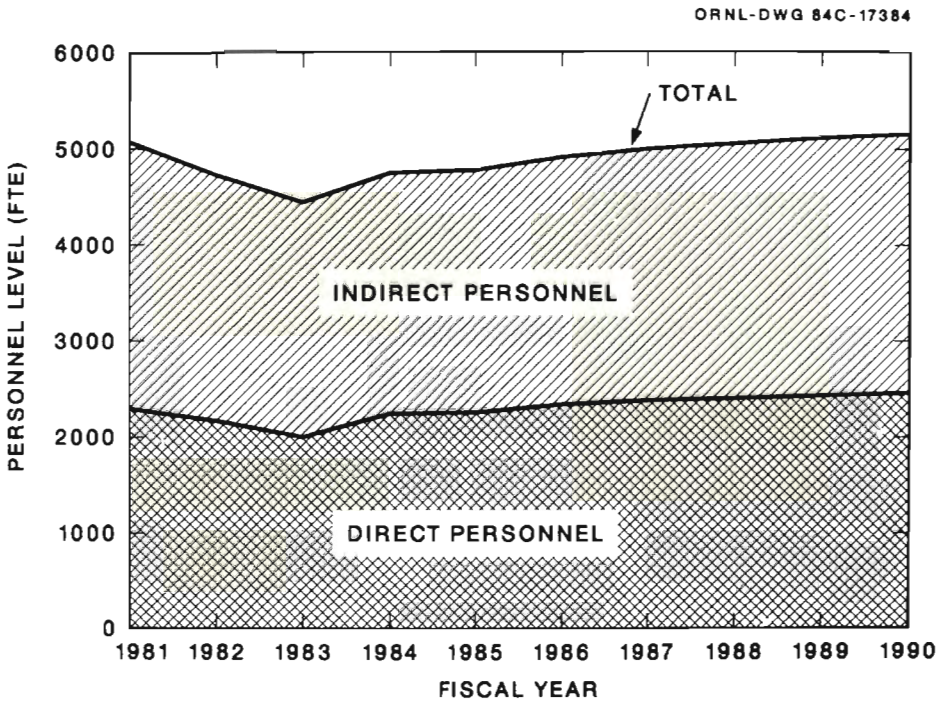


Fig. 5. Trends in personnel level. Figures for full-time equivalents (FTEs) from 1985 to 1990 are projections.

Scientific and Technical Programs

SCIENTIFIC AND TECHNICAL PROGRAMS

Department of DOE (DOE) Programs

Office of Energy Research (OER)

The Laboratory's major research programs in the basic physical sciences, fusion energy, and biomedical and environmental sciences areas are supported by OER. By providing roughly 40% of the Oak Ridge National Laboratory (ORNL) operating budget, OER is the largest single sponsor of research at ORNL (Table 1).

Table 1. Office of Energy Research major program summary[a]

($ in millions—BA)

B&R code	Major program	FY 1983	FY 1984	FY 1985	FY 1986
AT	Magnetic Fusion	76.04	65.66	54.80	68.30
HA02	Biological and Environmental Research	25.92	29.67	27.22	39.90
KA	High-Energy Physics	0.64	0.61	0.48	0.50
KB	Nuclear Physics	9.66	10.92	11.07	13.01
KC	Basic Energy Sciences	48.05	52.82	56.26	79.44[a]
KD	Energy Research and Analysis	1.25	0.96	0.60	0.60
KE	University Research Support	0.19	0.08	0.50	0.98
Total		161.76	160.75	150.93	202.73
Percentage of total Laboratory funding—BA		45.7	40.6	37.6	43.7

[a]Figures include operating BA, capital equipment, and funded/budgeted construction, if any.
[b]Includes $6.2 million for High Flux Isotope Reactor–II construction-related research and development.

AT—Magnetic Fusion

The Fusion Program at ORNL is a major component of the U.S. national fusion program, and it contributes in nearly all aspects of magnetic fusion research. The goal of the national fusion program is to determine whether the nuclear energy of the light elements, mainly hydrogen isotopes and lithium, can be released for useful purposes. The key issues at the current stage of the program are the understanding of the behavior of high-temperature hydrogen isotope plasmas; the develop-

ment of magnetic configurations that confine plasma effectively and have attractive engineering features; the development of the technologies for producing, heating, and controlling such plasmas; the design of future confinement facilities; and the development of the technologies that will be required for magnetic fusion to move through the engineering phase into the commercial phase. The centerpiece of the future program in the next 15 years is a proposed deuterium-tritium–burning tokamak designed for ignition and long-pulse equilibrium burn. An expanding role for ORNL is foreseen in all areas of this exciting new national project.

Support for the contributions of the ORNL Magnetic Fusion Program comes in three areas: Applied Plasma Physics (AT05), Confinement (AT10), and Development and Technology (AT15). Major changes of the past year that affect the future ORNL program are the completion of the Elmo Bumpy Torus (EBT) program and the Impurity Studies Tokamak Experiment (ISX-B). As these confinement programs wind down, part of that effort will switch to increasing the support of four programs: the national ignited-plasma tokamak project, the Tokamak Fusion Test Reactor (TFTR) at Princeton Plasma Physics Laboratory (PPPL), the development at ORNL of radio frequency (rf) heating technology, and the Advanced Toroidal Facility (ATF) program at ORNL. Work will continue on theory, improving the bumpy torus concept, and on other aspects of technology such as pellet fueling, neutronics, environment, materials and superconducting coils.

The Applied Plasma Physics subprogram includes theoretical studies to formulate and apply models of plasma behavior in various confinement systems (in recent years tokamak, stellarator, EBT, and reverse field pinch). This activity also encompasses the development of a data base for atomic physics and the development of diagnostic devices and technologies. In the tokamak and stellarator areas, work will continue to develop theory, both for comparison with experiment and for predictive calculations, in the areas of magnetohydrodynamics (MHD), heat and particle transport, and heating and fueling. Studies of critical issues will be made for the Elmo Bumpy Square (EBS). Studies of advanced systems such as ATF-2, the ignited-plasma experiment, and reactors are planned. In the atomic physics program a powerful new source of multiply charged ions has been completed. The measurement of atomic cross sections on this device coupled with theory will sustain a vigorous program in this area for a number of years. In a separate program a diagnostic device for measuring fusion alpha particles will be developed.

The Confinement Systems activities have traditionally included experiments and design studies in both the EBT and toroidal plasma configurations. Studies during the past two years on the EBT-S experiment have led to a much better correspondence in detail of theory and experiment. At the same time they support a lower estimate of confinement capability than previous estimates. The imaginative EBS configuration has been proposed as the new focus of this program. The EBS utilizes hot electron rings in bumpy straight sections combined with high field corners, which minimizes the effects of toroidal curvature on drift orbits. The EBS was reviewed, along with other alternative concepts, by the Magnetic Fusion Advisory Committee and found to be an exciting concept justifying further support. Oak Ridge realizes that the EBS might not be approved because of national budget problems and, therefore, that the EBT work could be completed in FY 1984 and has made alternative plans for the EBT staff for FY 1985. However, work will continue on updating the EBS proposal, and it will be resubmitted for FY 1986 funding.

In the toroidal area the ISX-B program is being completed. Major contributions in the final year have included the study of the Z-mode improvement to confinement at high beta, MHD studies, plasma rotation and potential measurements (a collaboration with Rensselaer Polytechnic Institute), surface physics, diagnostic development, and pumped limiters. The device was closed down in

late FY 1984 following a test of a beryllium limiter for the Joint European Torus (JET) project. In late FY 1984, through FY 1986, the main part of the experimental group will move to PPPL, where ORNL researchers will play a major role in the TFTR program. Key personnel in the expanding stellarator program will remain to work at the ATF project with Martin Marietta Energy Systems, Inc., engineering personnel. The ATF design and construction are proceeding on schedule and will be available for the experimental program to start in early FY 1987; it is planned to operate into the early 1990s. A device with outstanding capabilities, ATF has the flexibility to study various magnetic configurations, and a project is now being proposed that will upgrade ATF to operate in steady state with a high-performance plasma. ATF will provide a major in-house focus for theory and experiment, diagnostics, and plasma technology.

The ORNL Development and Technology Program continues to make progress on all fronts. In the neutral beam area a prototype long-pulse source has been tested successfully. The Oak Ridge ion source was not chosen for these applications, and the program is being substantially reduced as the ORNL Plasma Technology Section turns its attention increasingly to the development of rf heating systems. An rf test facility, which is based upon the prototype EBT-P coils, has been approved for construction and will be in operation in 1986. Development of rf systems is planned for TFTR, D-III-D, ATF, and the ignited-plasma experiment. The pellet-injector program has developed both pneumatic and mechanical injectors capable of repetitively providing pellets at speeds of about 1–2 km/s. These injectors have been used in a collaborative program with the Massachusetts Institute of Technology on Alcator C to produce record levels of the plasma confinement parameter. A very successful collaborative program has also been completed with an ORNL pellet device on D-III at GA Technologies (GAT). The next phase of the program will concentrate on higher velocity pellets leading to a tritium pellet injector for TFTR.

In the Large Coil Program, the Large Coil Test Facility (LCTF) has been completed, and three coils have been delivered. The first test has been completed using the Japanese coil, which was built by Hitachi; the first U.S. coil, from General Dynamics; and the Swiss coil, which was built by Brown-Boveri. The General Electric coil is near completion in the Oak Ridge Gaseous Diffusion Plant (ORGDP) machine shop. All six coils, including those from Westinghouse and Siemens (European Economic Community), will be installed during 1985. Testing will continue through 1987.

In the plasma materials program, work has continued on pumped limiter operation, fluorescence measurements, and laboratory studies of plasma materials interactions. During the period from the end of the beryllium limiter test on the ISX-B to the start-up of the ATF, much of this work will be focused on the Textor tokamak (Federal Republic of Germany) and other tokamaks. In the radiation materials area, work continues in the High Flux Isotope Reactor (HFIR) and the Oak Ridge Research Reactor to test candidate first-wall and blanket materials. A multiyear collaborative program with the Japanese Atomic Energy Research Institute (JAERI) is under way. A lithium aluminate blanket module for tritium production was tested successfully in collaboration with Argonne National Laboratory (ANL). In the neutronics area, work continues in assembling computer codes and in calibrating the codes against model experiments with a 14-MeV neutron source. A collaborative program for neutronics on TFTR is under way with PPPL. The technical basis document for an Environmental Impact Statement (EIS) has been issued, and work will continue on finalizing a generic EIS for fusion.

The Fusion Energy Design Center (FEDC), which is managed by ORNL, involves substantial collaboration with a number of U.S. industries, national laboratories, universities, and foreign

countries. FEDC is a major contributor to the planning, design, and engineering of the burning core devices that are candidates for the next major focus of the U.S. Magnetic Fusion Program. The center also performs the engineering studies for the U.S. contribution to the International Atomic Energy Agency–International Tokamak Reactor (IAEA-INTOR) activity. In addition, in collaboration with Lawrence Livermore National Laboratory (LLNL), a significant effort is devoted to the next phase of the tandem mirror program. This work is expected to continue for a number of years, and it may well be extended to include supporting studies of other concepts.

In the program for an ignited-plasma device, the Fusion Energy Program at ORNL is providing leadership in coordinating the research and development (R&D) activities. Through this work, the FEDC effort and support to other areas, the ignition experiment is expected to be an increasingly important part of the ORNL program in future years.

HA02—Biological and Environmental Research

OER's Office of Health and Environmental Research (OHER) continues to provide the largest portion of funding (57%) for the biomedical and environmental sciences programs at ORNL. During the past several years, some program elements have been lost, and the size of the staff has been reduced significantly because of reduced budgets and less than cost-of-living increases in many areas. We believe, however, that this trend has leveled out. Beginning in FY 1984, the HA02 (Environmental Research and Development) and HB (Life Sciences Research and Nuclear Medicine Applications) programs were consolidated under the single activity code HA02 (Biological and Environmental Research).

The goals of the HA02 Program are (1) to study the interaction of energy-related physical and chemical agents with living organisms, including their transport, chemical evolution, adverse health effects, and ultimate fate in humans and their environment; (2) to develop a knowledge base through basic research programs; and (3) to transfer research findings and technological developments outside the laboratory.

Research areas in biology include radiation biology, carcinogenesis, mutagenesis, genetics, chemical interactions and effects, and animal toxicology. This research is conducted mainly in the Biology Division. Environmental science research covers environmental toxicology, hydrology, environmental risk analysis, geochemistry, geology, carbon dioxide, and acidic deposition. Health and safety research encompasses epidemiology, health risk analysis, radiation and chemical dosimetry, nuclear medicine, and the development of instrumentation for sensitive detection and monitoring of chemicals.

In addition, three unique user facilities are supported by the HA02 Program: the Health Physics Research Reactor (HPRR), the Oak Ridge National Environmental Research Park, and the Bioprocessing Research Facility (BRF) user resource. The latter integrates physical resources from the Biology and Chemical Technology divisions to include bioreactors, a flow cytometry laboratory, large volume fermenters, and centrifugal analyzers. Users of these facilities include staff of national laboratories, industry, and students and staff from universities.

The ORNL HA02 Program is among the most multidisciplinary life sciences research programs in the nation and covers a broad range of both basic and applied studies. Overall, the HA02 program at ORNL is expected to experience limited growth in this planning cycle, although some subprogram elements are proposing modest expansion.

The Biology Division is a major contributor to DOE's Complex Chemical Mixtures Research Program. Because many of the energy-related materials of potential importance for human health

are mixtures of chemicals rather than single substances, OHER has implemented a new initiative to elucidate the mechanisms of interaction among compounds in complex mixtures. ORNL has been given the lead role in the investigation of the adverse health effects that can be attributed to model compounds within the mixtures. Therefore, the research emphasis at ORNL is shifting from evaluating the toxic effects of mixtures on experimental animals to the investigation of hypotheses about the inhibition or enhancement of toxicologic effects of chemical substances when they are components of mixtures. These studies will provide a rational basis for assessing potential health risks from exposure to complex mixtures.

We have accelerated our research efforts in protein engineering, which is described in more detail in New Initiatives.

The main theme in our biological research efforts, namely experimental genetics, will continue at about the same level as in FY 1984. Experiments will continue to elucidate the nature of genetic materials at the molecular, genomic, and chromosomal levels of organization and to learn how gene expression is controlled in health and disease. At the molecular level, the accelerated effort in protein engineering combines the expertise of molecular biologists and biochemists to focus on a promising field of research made possible by technologic advances in genetic engineering. At the level of the whole animal, the research will continue to concentrate on the mouse, the only mammal besides human beings for which sufficient background knowledge exists for meaningful genetics research. This research takes advantage of a unique and invaluable resource at ORNL, a collection of 2×10^4 genetically defined mice—the only federal resource of this sort in existence. Other research efforts in biology share overlapping interests with genetics research, thus promoting interdisciplinary collaboration. In carcinogenesis research, for example, considerable emphasis is placed on the role of cellular and/or viral genes (oncogenes) whose presence and expression is associated with the conversion of healthy cells to cancer cells. Research on toxic damage to organ systems includes the quantitative interactions of energy-related substances with genetic materials.

Biophysics research in the Biology Division will be concentrated for the next several years on studies of genetic materials and of cellular membranes. In addition to investigations of the physical properties of DNA, genes, and chromosomes, the studies will address structural alterations of DNA by chemicals and DNA-adduct formation. We are using electron microscope tomography and small-angle scattering (neutron and X-ray) to study macromolecular structure, with particular attention to cell membranes and their function in health and in disease.

Environmental research is designed to increase the ability to predict transport and effects of energy-related contaminants in the environment. Basic information is developed on mechanisms that govern ecosystem function, particularly in biochemical cycling studies on forested landscapes (Walker Branch Watershed) and in southeastern reservoirs. Through utilization of process studies with stable elements, radionuclides, and trace organics as well as mathematical simulation models, data and methodologies are developed that enhance our ability to site and operate energy systems in a cost-effective and environmentally safe manner. We will continue to expand our expertise in hydrology and geochemistry in support of the developing DOE programs in subsurface transport of hazardous substances. In the area of global environmental concerns, ORNL has become a center of expertise in the investigation of ecological transport and effects and in the assessment of acid deposition. We propose to expand our research efforts to encompass the role of terrestrial-aquatic linkages in the processing of atmospheric pollutants. As with most technology-related pollution problems, an interdisciplinary approach is required for planning and conducting the appropriate research. The Environmental Sciences Division is currently doing research for OHER on biogeochemical cycling in Walker Branch Watershed and on hydrologic transport of trace elements in

contrasting watersheds. ORNL serves as an important research and modeling center for OER in the global carbon cycle and also provides support for program planning and evaluation. In collaboration with ANL, Brookhaven National Laboratory (BNL), and Pacific Northwest Laboratory (PNL), ORNL staff members have prepared a large proposal, in response to encouragement from DOE, entitled *The Role of Terrestrial-Aquatic Linkages in the Acidification of Surface Waters.* The proposed research tests a conceptual model of surface water acidification and recovery for a forested watershed. Two approaches will be taken (1) to demonstrate the extent and rates of integrated watershed responses, given certain ecosystems characteristics and differing levels of atmospheric deposition of acidity and (2) to test under what conditions and at what rates the individual steps involved lead to the modeled effects. The first approach uses tracers and manipulations on a hillslope, subcatchment, or watershed level to demonstrate integrated watershed responses. The second approach is organized around specific processes occurring within the different ecosystem compartments. Test results will then be used to parameterize watershed-level models for testing integrated watershed reponses.

During the next five years, the global carbon cycling program activities will encompass new research in terrestrial carbon dynamics and global carbon cycle modeling, as well as new responsibilities in carbon cycle research management for DOE. Research efforts will be focused on assembling and implementing disaggregated (multidimensional) models of the global carbon cycle. Management activities will involve the gradual assimilation of a greater share of contract execution activities for the DOE Carbon Cycle Research Program, particularly in the areas of oceanic data collection and analysis. This broad array of activities and expertise is necessary for developing the information and models needed to provide accurate projections of carbon dioxide (CO_2) buildup in the atmosphere over the next century from both natural and anthropogenic sources.

The Carbon Dioxide Information Center (CDIC) supports the nation's CO_2 research program and cooperates in information exchange with the international scientific community by addressing global atmospheric CO_2 problems. It is sponsored by DOE's Carbon Dioxide Research Division and administered by the ORNL Information Division.

CDIC's objective is to provide a focal point for the compilation and distribution of CO_2 related information under systematic quality control. The center's main function is to serve the information needs of researchers evaluating the effects of increased CO_2 on the global carbon cycle, climate, and vegetative response and the indirect effects of elevated CO_2 levels. The current national CO_2 research program required CDIC to participate in R&D activities in addition to its information dissemination function.

Research in the Health and Safety Research Division (HASRD) is directed toward attaining improved knowledge of the detection and bioeffects of energy-related chemical and physical agents, particularly in terms of the overall impact on human health. The majority of the programs deal with fundamental theoretical and experimental research sponsored by the DOE Office of Health and Environmental Research. HASRD also conducts work for other federal agencies as it relates to DOE-OER-OHER interests.

Though the division's activities are very broad in scope and diverse in style and content, they are nevertheless founded on their relevance to problems associated with detrimental effects of energy production on human beings and their environment; development of measurement capabilities that meet present and future needs for assessing exposures of people to various insults; and development of assessment methodologies that allow quantitative judgments to be made on present and future impact of various energy strategies, energy production levels, and possible energy-related mishaps.

The physical and technological research activities under OHER support are directed toward increasing our knowledge of the interactions of potentially hazardous agents with biological and environmental systems and toward ensuring a technical capability for characterizing and quantitatively measuring such agents in various settings. Much of the work stems from long-range goals associated with a desire to make informed assessments of or to take effective steps toward the amelioration of potential health and environmental risks associated with new and existing energy technologies. This program consists of studies involving the structures and properties of materials of biological or environmental importance, the physical and chemical mechanisms that govern transport and chemical transformations of pollutants in the atmosphere-hydrosphere-biosphere, and the details of direct interactions of harmful agents with biological materials.

Included in the scope of this work are theoretical and experimental studies of interactions at the atomic, molecular, and macroscopic levels in solids, liquids, gases and on solid surfaces and solid-liquid interfaces. Also, detailed Monte Carlo studies are made of the physical and chemical evolution of radiation-induced products in natural media.

Strong emphasis is given toward development of techniques that provide advanced instrumentation for characterizing and sensitively detecting a wide variety of chemical species. Included in this effort are unique applications of laser optical techniques, ultraviolet and soft X-ray spectroscopic techniques, and electron-beam microlithography.

A continuing research activity is the development of new instruments and measurement techniques to support evaluation of the potential health and environmental impact of developing energy technologies. Results of this research have led to cost-effective luminescence techniques for rapid screening of samples containing polynuclear aromatic compounds as well as portable instrumentation for on-site use at operating facilities. The DOE-OHER–funded developmental research has resulted in support from other agencies and organizations for applied studies. Transfer of this technology to the commercial sector is an important objective.

Coupled with the emphasis on instrumentation for occupational monitoring is the investigation for biological indicators of exposure to chemical pollutants and subsequent physiological response.

The division is responsible for the HPRR, a unique research facility that is one of the most heavily used DOE user facilities at ORNL. A small, unshielded, unmoderated, fast reactor, the HPRR yields up to 1×10^{17} fissions in the pulse mode and 10 kW in the steady-state mode. The program using the HPRR features research in radiobiology and dosimetry and technology transfer with criticality alarm testing, education, training, and instrumentation development.

The Nuclear Medicine Program has received widespread recognition for the design, synthesis, and animal testing of new radiopharmaceuticals for use in clinical nuclear medicine and other radiolabeled agents for fundamental biomedical research. A major effort of this program is the development of new, improved radiolabeling techniques and the design of new tissue-specific agents for the evaluation of tissue anatomy, perfusion, and metabolism. The Nuclear Medicine Program is complemented by an active extramural collaborative effort through cooperative programs with medical institutions such as Massachusetts General Hospital and Boston's Children's Hospital.

Indoor air quality and water quality as related to human health are receiving increased attention at the national level. Because of the division's multidisciplinary capabilities for defining exposures and effects, activities in these areas are increasing. Studies in indoor air quality have matured from a new initiative status to an established collaborative program with multiagency funding. The first phase of epidemiological studies on drinking water quality and human health has been completed. These studies have led to formulation of new hypotheses concerning associations between

drinking water parameters and human health. Funding has been developed to continue these studies.

Program Construction. ORNL is proposing four line-item construction projects for the HA02 program.

HA02—Proposed construction summary
($ in millions)

	FY 1984	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990	TEC
Health and Safety Research Laboratory				3.0				3.0
Upgrade air supply system, Building 9210, part I				3.2				3.2
Toxic Substances Laboratory and Animal Facility				7.2	29.6	1.7		38.5
Upgrade air supply system, Building 9210, part II					3.0			3.0

The largest item, the Toxic Substances Laboratory and Animal Facility, is a new facility for handling toxic materials. The purpose of the project is to provide specialized laboratories and space for animals to be used in investigating acute and chronic effects of energy-related toxic chemicals and metals. The development and maintenance by DOE of a program to study toxic effects of such materials are essential for the future protection of energy industry workers, the general public, and the environment. DOE's recently established toxicology program requires that we have new laboratory and animal space designed specifically to enable personnel to handle toxic materials safely. This proposed facility will begin to implement the Laboratory's long-range goal to consolidate to the maximum extent the life sciences research activities at the west end of the ORNL Bethel Valley site. Several additional major facilities will be required in the out years to complete the phased relocation of the Biology Division from Y-12 to the Life Sciences Complex. The specifics of these facilities are currently being developed and will be included in a future Institutional Plan.

KA—High Energy Physics

The High Energy Physics group provides an essential service to the physics community by measuring and calculating multigroup cross sections and transport phenomena for a wide variety of applications. Nuclear cross-section models and nucleon-meson transport methods are developed that facilitate the design of high-energy particle detection systems, such as ionization calorimeters and total absorption calorimeters. Design data as well as detailed designs are provided to outside experimental groups engaged in detector construction. A parallel effort provides the information required for meeting radiation shielding requirements. These activities are projected to continue with increased collaborations with southeastern universities.

Our long-standing collaboration with The University of Tennessee in experimental high-energy physics research will continue but with a larger share of operating budget borne by the university. The ORNL portion of this work will involve one person-year annually.

KB—Nuclear Physics

The principal activities in the Nuclear Physics Program are the operation of the Holifield Heavy Ion Research Facility (HHIRF) as a national user facility and the in-house heavy-ion research program, which is centered on this facility. In addition, this program supports the effort in nuclear theory, light-ion nuclear physics, and resonance neutron capture studies. Technical assistance is also being provided to the Continuous Electron Beam Accelerator Facility project. A modest increase is proposed beginning in FY 1986 to provide increased utilization of the HHIRF. In the period FY 1986–FY 1987 we also hope to add two theorists to strengthen significantly the theory effort supporting the research programs. This latter effort will allow us to capitalize more fully on The University of Tennessee–ORNL Distinguished Scientist Program. A new trend beginning in FY 1984 will be an experimental effort in relativistic heavy-ion physics. This portion of the experimental program will participate in research at the PS/SPS accelerators at the European Organization for Nuclear Research and the AGS accelerator at BNL. A companion effort will begin in FY 1984 to develop criteria and design for a relativistic heavy-ion collider. This facility would provide ion energies to 10 GeV/A and would be a major construction addition to the HHIRF. This construction would be timed to begin toward the end of the period (FY 1989–FY 1990) and would require addition of several accelerator specialists. A firmer schedule and an estimate of proposed construction cost will be prepared for the 1986 Institutional Plan.

Program Construction. An Accelerator Improvement Modification (AIM) project for the HHIRF is proposed as follows:

KB—Proposed construction summary
($ in millions)

	FY 1984	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990	TEC
AIM								
25 MV Tandem extended tube upgrade			0.52					0.52
25 MV Tandem upgrade				0.60				0.60

KC—Basic Energy Sciences

The Nuclear Sciences subprogram (KC01) funds work primarily in four areas: nuclear data measurements with the Oak Ridge Electron Accelerator, research in heavy-element chemistry, electromagnetic isotope separation using the calutrons, and special isotope production (HFIR) and transuranium (TRU). The combination of the HFIR and TRU facilities is the unique source of isotopes for transplutonium research in the free world. HFIR-TRU production of the isotope ^{254}Es, and subsequent research in the chemistry of transeinsteinium elements, is expected to be an increasingly important activity in the future. Isotopes separated in the calutrons are essential to a wide spectrum of research activities and to the production of a variety of radiopharmaceuticals.

Overall KC01 operating levels are not expected to change significantly over the period of FY 1986–FY 1990. However, heat exchangers for the HFIR and power supplies for the calutrons will need to be replaced to ensure continued operation of these facilities through 1990.

Built in 1965, the HFIR was for some time the world's premier research reactor. This title is now held by the Institute Laue-Langevin reactor in France. Preliminary studies funded by ORNL

have determined that by redesigning the reactor core, increasing power, and adding experimental facilities, a new version of the HFIR, HFIR-II, could be constructed that would place the United States once again well in the forefront by the mid-1990s.

The accompanying proposed construction budget table summarizes the outlays associated with this objective, through FY 1990. Costs through FY 1989 are associated with R&D toward a conceptual design and safety analysis, with detailed site-specific engineering design work beginning in FY 1989. Further details on the HFIR-II proposal may be found in New Initiatives.

Research sponsored by the Materials Sciences (KC02) subprogram provides a deeper understanding of the properties of materials and develops new materials of potential benefit to the energy technologies. A variety of techniques, including electron microscopy; neutron, X-ray, laser light, and synchrotron radiation scattering; ion bombardment; and laser processing, are employed to characterize materials and to identify specific physical properties that govern, for example, corrosion, radiation, fracture resistance, toughness, superconductivity, and photovoltaic conversion efficiency. The understanding gained is used in tailoring materials modifications to achieve more desirable properties. Theoretical studies proceed in parallel with experimental research. Increased emphasis and growth are projected through 1990 in several key areas: research on new alloys and toughened ceramics at the High Temperature Materials Laboratory (HTML); neutron scattering at the HFIR and the study of neutron-induced defects at the National Low Temperature Irradiation Facility now under construction; and surface modification studies using ion beams and laser processing at the Surface Modification and Characterization Center. An imaging atom probe under construction will provide significant new capabilities to several activities in these areas. The design and construction of instrumentation for materials science research with HFIR-II, discussed in New Initiatives, are projected to become an increasingly important activity in the latter part of the 1980s.

The Chemical Sciences subprogram (KC03) supports research in chemical physics, atomic physics, chemical energy, separations and analysis, and chemical engineering. Activities include studies of chemical processes at the high pressures and temperatures encountered in energy conversion facilities; fuel cycle chemistry, the chemistry of improved extractants for the separation of metals from solutions; and of coal structure and reactivity. Accelerator-based studies of high-energy atomic collisions are conducted using the En and HHIRF tandem accelerator facilities. The development of improved measurement techniques involving microwaves, positron beams, electron spectroscopy, optoacoustic phenomena, mass spectrometry, and laser-based methods receives considerable emphasis. The proposed construction of an Analytical Mass Spectrometry Laboratory (AMSL) at ORNL would permit relocation of our sophisticated spectrometers from their current location at the Y-12 site, rendering them much more accessible to other Chemical Sciences–supported activities. The move undoubtedly will enhance the effectiveness of all related research. Increased emphasis and growth are planned for research on the role of molecular bonding and structure in determining the equilibrium, kinetic, and interfacial behavior of solvent-extraction systems. Growth is also projected in the study of multiphase transport phenomena and in the investigation of atmospheric chemistry related to acid deposition.

Work in the Engineering, Mathematical and Geosciences subprogram (KC04) includes the development of new mathematical and statistical methods of analysis, studies of geochemical processes that promote transportation and redistribution of materials in the earth's crust, and research aimed at developing control technology for large complex engineering systems. The latter work is carried out at the ORNL Center for Engineering Systems Advanced Research, for which significant growth is projected. In the mathematics area, the development of new algorithms that exploit advances in parallel processor architectures will receive increased emphasis.

Biological Energy Research (KC06) addresses problems associated with evaluating the importance of species strategies of nutrient and photosynthate utilization and with a variety of biologically driven conversion processes of importance to energy technologies. Some growth is projected for this area.

Program Construction. Two AIM projects are approved for funding in FY 1984. A number of other Accelerator and Reactor Improvement and Modification (ARIM) projects are proposed. In addition, funding for an AMSL, a Solid State Sciences Research Laboratory, and for HFIR-II are proposed. Details of the HFIR-II proposal may be found in New Initiatives.

KC—Funded construction summary
($ in millions)

	FY 1984	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990	TEC
AIM								
Calutron	0.27							0.27
En Tandem	0.25							0.25

KC—Budgeted construction summary
($ in millions)

	FY 1984	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990	TEC
ARIM								
HFIR heat exchanger		0.30						0.30
AIP								
Bulkshielding reactor		0.20						0.20

KC—Proposed construction summary
($ in millions)

	FY 1984	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990	TEC
AIM								
HFIR Critical Facility			0.30					0.30
HFIR remote sampling			0.30					0.30
Beam lines for atomic physics, HHIRF			0.28					0.28
ORELA rf system				0.60				0.60
AMSL			3.40					3.40
HFIR-II			6.20	14.60	11.60	50.0	90.0	*a*
Solid State Sciences Research Facility					4.00	5.00		9.00

[a]Not yet determined.

KD—Energy Research and Analysis

Energy Research and Analysis activities support OER in technical and economic assessments of energy-related technologies and in technical assessments of DOE programs. No significant growth is projected for this program. It decreased in scope by about 50% in FY 1984, when the

technical support for the Energy Research Advisory Board (ERAB) was transferred to another laboratory, by mutual agreement, after the expected two-year program at ORNL was completed.

KE—University Research Support

The University Research Support Program (KE) seeks to stimulate cooperative research by the university community in ORNL activities. Financial support was provided to nearly 100 university-based researchers in FY 1983 under the auspices of the program, and significant growth is projected for the future. The enlarged portion of the program is targeted at recently appointed university faculty members of outstanding promise and their students and postdoctoral associates who frequently find it difficult to gain independent research support at the earlier stages of their careers. The program will enable approximately 25 university groups to become immediate, full-fledged partners in work at the science frontier. At the same time, universities will be able to provide their recent appointees with unique research opportunities while retaining them in teaching positions. The program establishes a procedure by which the university and DOE-related recommendations of recent administration review committees, including the Federal Laboratory Review Panel (White House Science Council) and the University Programs Panel (ERAB), can be implemented.

Assistant Secretary for Nuclear Energy (ASNE)

The ASNE is the major sponsor of applied nuclear research and the second largest sponsor at ORNL. Programs funded through this office are multidisciplinary in nature and include, as major activities, advanced nuclear systems, breeder reactor systems, convertor reactor systems, remedial action programs, nuclear waste management, and nuclear fuel cycle (Table 2).

Table 2. Assistant Secretary for Nuclear Energy (ASNE) major program summary[a]

($ in millions—BA)

B&R code	Major program	FY 1983	FY 1984	FY 1985	FY 1986
AE	Advanced Nuclear Systems[b]	2.70	2.28	1.93	4.32
AF	Breeder Reactor Systems[b]	10.93	10.08	9.84	10.46
AG	Convertor Reactor Systems[b]	7.11	5.40	6.11	7.43
AH	Remedial Action Programs	1.52	2.93	3.70	5.05
AP	Commercial Nuclear Waste Management	0.24	0.46	0.38	0.16
AS	Nuclear Fuel Cycle[b]	24.29[c]	27.81[c]	15.60[c]	16.00[c]
CD	Uranium Enrichment	0.40	0.33	0.00	0.00
Total		47.19	49.31	37.56	43.42
Percentage of total Laboratory funding—BA		13.3	12.5	9.3	9.4

[a]Figures include operating BA, capital equipment, and funded/budgeted construction, if any.
[b]Substantial funding shifts are expected.
[c]Figures include operating BA assigned to GA Technologies, Inc.

AE—Advanced Nuclear Systems

Improved materials for space missions and terrestrial applications that utilize heat generated by isotopic power devices are being developed and evaluated. Activities have included the production of iridium-alloy-cladding blanks to contain heat-generating radioisotopes and carbon-bonded carbon-fiber (CBCF) insulators to achieve 1300°C operating temperature. In anticipation of resumed production in FY 1986, ORNL is maintaining its production capability and inventory of iridium. In the interim, technology improvements are being pursued. These include (1) development of a process to produce CBCF from a new starting product, (2) development of a consumable arc-melting technique and determination of processing latitudes for the iridium alloy, (3) publication of an Isotope Space Power Materials Handbook, (4) nondestructive-examination support for manufacture of advanced thermoelectric elements and the iridium alloy blanks, and (5) evaluation of measurements of the diffusivity and steady-state thermal conductivity of CBCF.

ORNL has assumed a lead role in the development and characterization of refractory alloys in the SP-100 Program on 100 KW(e) and multimegawatt fission reactor concepts sponsored jointly by DOE, the Department of Defense (DOD), and the National Aeronautics and Space Administration (NASA). An ORNL-designed system involving a direct potassium Rankine cycle reactor and flywheel energy storage for delivery in 1×10^4 MW/s energy pulses was selected as a reference concept in the formulation of a multiyear national technology development plan for multimegawatt applications. Efforts continue to establish a substantial role for ORNL in the generic technology areas of Rankine cycle, reactor shielding, controls and measurements, core design support, and energy storage.

AF—Breeder Reactor Systems

The Breeder Reactor Systems program supports the liquid-metal reactor (LMR) concept, with continued efforts in the base-technology areas of materials, measurement and control, physics, and safety. In each of these areas, increased emphasis is being placed on activities in support of innovative, low-cost, passively safe designs.

As lead laboratory for the national Improved Materials Program, we will continue efforts to develop and code-qualify the modified 9 Cr–1 Mo steel to obtain a greater understanding of the behavior of advanced structural alloys in LMR environments, and to develop improved design methods and criteria.

Measurement and control activities will support the development and proof testing of key high-risk, high-payoff components and systems such as high-temperature fission counters and automated noise surveillance and diagnostic systems. The physics work will concentrate on analysis and validation of shield designs. In the reactor safety area, thermal hydraulics data pertinent to the understanding and management of shutdown heat removal will be obtained from the Thermal Hydraulic Out-of-Reactor Safety (THORS) facility. Also, computerized data bases for safety analysis (SACRD) and component reliability (CREDO) will continue to be maintained. Work in each of these areas will continue to be coordinated with comparable efforts in other advanced converter technology programs.

The Nuclear Standards Management Center, which is part of the Program Assurance effort in the LMR program, will continue to promote the development of consensus industrial standards, augmented by special program standards as required, to ensure that the information and experience gained in all nuclear programs, including fuel recycle and waste management, are documented

appropriately and made available to the private sector. Program support for DOE's unusual-occurrence-report activities will be continued.

Program Issue. The U.S. Civilian Reactor Development Program currently is being reconstructed to more broadly address advanced converter reactor systems based on water and gas as well as sodium coolants. While the sodium-cooled breeder reactor is recognized as probably being needed for long-term, essentially inexhaustible energy supply, current predictions of uranium use reduce the pressure for early breeder development. As a consequence, considerable uncertainty surrounds the future of our LMR base technology program, which currently supports about 60 direct full-time equivalents (FTEs). In any event, it is our intent to support DOE in this transition phase and to offer our broad expertise in fission reactor technology for the restructured program.

AG—Converter Reactor Systems

The goal of the U.S. Civilian Reactor Development program is to ensure the nation's energy future through the establishment of attractive and viable nuclear energy options and the necessary technology base. While current light-water reactors (LWRs) are safe relative to other energy options, economic and regulatory problems related to safety and quality issues contribute significantly to the lack of new plant orders.

It is therefore timely to develop high-temperature gas-cooled reactor (HTGR) options for the intermediate term to take advantage of greater opportunities for robust, passive, and demonstrable response to accident conditions (inherent safety) and dramatically new fabrication, construction, and regulatory options that will lead to attractive economics, including low and fixed capital cost, short construction time, and low operating cost.

The primary emphasis will be on the development of a modular high-temperature reactor (MHTR). MHTR concepts were initially developed in the Federal Republic of Germany and have been improved in the United States. Current concepts consider both prismatic and pebble-bed fuel and both prestressed concrete and steel reactor vessels. Pebble-bed fuel allows on-line refueling, and steel vessels facilitate unit factory fabrication. Low core–power density (4 W/cm^3) and unit power levels of 100 MW(e) in modular systems [500 MW(e) in annular systems] allow passive decay heat removal systems. This combined with the safety advantages of inert gas coolant should provide demonstrable safety with such wide margins that safety-related regulatory issues are greatly simplified. Economic savings will result from high-quality automated factory fabrication, streamlined licensing, standardized construction, non-safety-grade balance-of-plant, incremental financing, and reduced rate-base impact. The program target will be a full-scale prototype MHTR in operation by 1993.

The primary mission of this activity is to provide technological expertise in support of the national HTGR program to develop HTGRs for electricity production, cogeneration, and high-temperature process heat. The program direction is to develop HTGRs having a high degree of passive safety to improve their economics and reduce risk. Within the national HTR program, ORNL has the lead responsibility for the Base Technology Development Program. The technical activities include (1) performing qualification tests of HTGR fuel performance and fission product behavior under extreme accident conditions; (2) providing basic data on the mechanical, physical, and chemical behavior of HTGR materials, including metals, ceramics, graphite, and concrete; (3) performing component testing and development on the core support structure and on the ceramic pads on which the core posts rest; (4) providing analytical and experimental evaluation of the effectiveness of the

reactor shielding design; (5) evaluating reactivity coefficients associated with various reactor conditions; and (6) providing technical evaluations and assessments in specific as well as broad areas.

Recognizing the extended delay in LWR plant orders and the eventual need for more advanced reactor systems, we propose new activity to examine several new and modified concepts. Emphasis will be placed on lower costs, improved fuel utilization, application to process and district heating, improved siting capability, and improved thermal efficiency. Concepts to be considered include sodium- and gas-cooled reactors and modified LWRs, such as the Process Inherent Ultimate Safety concept proposed by Sweden. This modest effort will be coordinated with similar studies by the Tennessee Valley Authority (TVA), the Electric Power Research Istitute (EPRI), and other segments of the industry.

The activities in the Emergency Waste Management Program (AG30) involve participation in recovery operations for the Three Mile Island Unit 2 (TMI-2) reactor system as part of the Technical Assistance and Advisory Group. Special technical support services are performed for the recovery operation. Two small tasks on specific problems were completed in FY 1984, and the technical participation is expected to be closed out by the end of FY 1985.

An ancillary task, part of the LWR subprogram (AG36), is to reexamine the advantages of a small LWR in meeting the growth requirements of the utility industry. Other LWR tasks include annual updating of the energy economic data base, economic analyses of nuclear versus other energy sources, and a region-specific study of the electric utility industry. The latter is aimed at assurance of adequate future electric power. The increases in funding for the AG Program reflect a modest increase in the evaluation and assessment activities and consolidation of funding in this area. Funding for the HTGR program is expected to increase.

The Converter Reactor Systems Program has achieved several major accomplishments in FY 1984. The Core Support Performance Test has been operated under restricted conditions and has been found to be an excellent tool for obtaining information on graphite corrosion behavior under reactor operating conditions. We have shown that certain HTGR fuels show promise for retaining fission products such that less than 1×10^{-4} of the fission products are released from the fuel under extreme operating conditions. Our research with graphite has shown that core support graphites can be developed that have very low oxidation rates when exposed to water vapor. Our work with concretes has indicated that high-strength concrete can be developed using a variety of aggregate material.

AH—Remedial Action Programs

Major activities in Remedial Action Programs (RAPs) involve management of surplus facilities and the conduct of radiological surveys at inactive mill tailings sites, facilities formerly used under contract with the Atomic Energy Commission (AEC), and private properties near these sites. Identification, evaluation, and documentation of the present radiological status of sites involved in DOE's RAPs are performed to provide a basis for the reduction of health impacts of fuel cycle activities. The Uranium Mill Tailings Remedial Action Program (UMTRAP) maintains an office managed by the Health and Safety Research Division in Grand Junction, Colorado, to perform its activities in a cost-effective manner. It is considered by DOE a critically important program, as manifested by the FY 1985 finding level of $2.85 million, an increase of $1.65 million over FY 1984. Advancing state-of-the-art equipment and methodologies is an integral part of this work. The radiological survey efforts will increase substantially in FY 1985 and again in FY 1986 to a level of

effort sufficient to support remedial action work, and will continue at a stable level until completion in about 1990. The surplus facilities effort is expected to increase gradually, beginning in FY 1986 when decommissioning assessments of the Molten Salt Reactor Experiment are initiated. The small task for geophysical studies in support of remedial actions at the Manhattan Engineering District and other AEC sites is expected to continue at present levels.

AP—Commercial Nuclear Waste Management

The Commercial Nuclear Waste Management program provides minor support for the Integrated Data Base (IDB) and funds three tasks on low-level waste technology development. These tasks include consultation with the Commonwealth of Kentucky for demonstration of in situ grouting of a waste trench and the conduct of a licensing demonstration for a mock site. The third task, which comprises the field demonstration of geophysical diffraction tomography to provide quantitative information on subsurface geophysical properties, was supported by Program AR during FY 1983 and transferred to this program in FY 1984. These tasks are expected to be completed in FY 1985.

AS—Nuclear Fuel Cycle

The Consolidated Fuel Reprocessing Program (CFRP) plays an important role in the future of nuclear power in the United States. For about ten years, ORNL has been developing the technology for reprocessing spent fuel with the major emphasis on the special problems of breeder fuels. In this time the staff of experienced engineers have developed improved concepts and techniques that are recognized worldwide. Many similar improvements are being incorporated in foreign reprocessing facilities. ORNL is leading the world in efforts to develop improved methods for remote maintenance in reprocessing facilities. Possibly of even greater importance is that this remote technology can be applied to a wide variety of activities that must be carried out in hazardous environments, such as fusion, waste disposal, decommissioning, and cleanup of reactors and other nuclear facilities.

The major emphasis over the past two years has been on initiating a major reprocessing equipment demonstration (cold) in the Integrated Equipment Test (IET) facility at ORNL. A parallel effort to design a hot engineering test facility, the Breeder Reprocessing Engineering Test (BRET), has also been under way. However, recent DOE decisions have deferred the BRET until the overall breeder strategy has been redefined. The ORNL CFRP is continuing component and operational testing and evaluation in the Remote Operation and Maintenance Demonstration and in the Integrated Process Demonstration portions of the IET facility.

ORNL is leading a major collaborative strategy study with HEDL to examine overall options and strategies for the fast reactor fuel cycle and to support innovative reactor design studies that DOE plans to initiate in FY 1985. The Secure Automated Fabrication facility and the proposed BRET facility located in the Fuels and Materials Examination Facility (FMEF) complex at Hanford are part of the study's evaluation, and expansion of their current capabilities is being investigated. Their potential role in the overall fuel cycle in support of the innovative reactor concepts will be examined.

ORNL will continue its active role in efforts to foster international collaboration and to examine the merits of cooperative fuel cycle projects in the future. Other countries hold to similar

courses. In Europe major international breeder fuel cycle projects are being considered; Europeans recognize the fuel cycle as one area where payoffs for collaboration will be great. Activities under the United Kingdom exchange continue. France and Federal of Republic of Germany have expressed interest in exchanges with the United States in this field, and exploratory discussions have taken place. Major new exchange agreements are being developed with Japan for collaboration in experimental criticality work and in application of remote technology. Japan's Power Reactor and Nuclear Fuel Development Corporation will provide major funding for the criticality program. Efforts to develop international cooperation will continue to increase the benefits and to reduce the research costs for the United States and the other participants.

Program Issue. A revised breeder program strategy must include an appropriate role for fuel cycle development activities. The BRET could be the reprocessing focal point by providing a real operating environment for the testing of advanced reprocessing technology under development from 1974 to 1984 at ORNL. Cancellation of the BRET without a suitable substitute hot development facility would represent one more major setback to nuclear fission in the United States. The implications must be carefully examined.

CD—Uranium Enrichment

Studies and analyses in support of the entire Nuclear Energy area are receiving support through Program CD in FY 1984 only. A new task beginning in FY 1984 also provides for assaying vegetation, soil, sediments, and water for uranium around the Portsmouth Gaseous Diffusion Plant. The data collected will be used to develop a mathematical model that describes uranium losses to the environment. A four-year effort is proposed, utilizing R&D staff and a minimum of supporting materials and services.

Office of Civilian Radioactive Waste Management (OCRWM)

ORNL's work for the new OCRWM is conducted under Program DB. The Nuclear Waste Fund program consists of two major components: Repositories (DB30) and Program Management and Technical Support (DB60) (Table 3).

Table 3. Office of Civilian Radioactive Waste Management major program summary[a]

($ in millions—BA)

B&R code	Major program	FY 1983	FY 1984	FY 1985	FY 1986
DB	Nuclear Waste Fund	0.67	1.83	3.01	4.25
Percentage of total Laboratory funding—BA		0.2	0.5	0.7	0.9

[a]Figures include operating BA, capital equipment, and funded/budgeted construction, if any.

DB—Nuclear Waste Fund

The Repositories portion of the Nuclear Waste Fund Program provides support for the continuation of the sensitivity and uncertainty analysis task for the waste isolation program and for the new sedimentary rock program, which will investigate the use of sedimentary rocks other than salt as hosts for a radioactive waste repository. During FY 1984–FY 1985 the ORNL Sedimentary Rock Program will conduct literature-based geotechnical investigations to recommend the most promising of a list of sedimentary rocks (argillaceous rocks, sandstone, limestone, anhydrock, and chalk) for further consideration as the host medium for a high-level waste repository. A decision by OCRWM to accept this recommendation would then initiate a formal site screening process leading to the nomination of a site in the most promising rock by the end of FY 1988 and subsequent in situ characterization of the site. The site screening and characterization process would involve extensive experimental activities (laboratory and field) and ultimately the sinking of shafts to characterize the proposed repository horizon. These activities will require significant expansion of program budgets and personnel.

The Program Management and Technical Support component provides support for the Transportation Technology Center at Sandia National Laboratory (SNL) and major support for the IDB. The transportation task addresses the movement of commercial nuclear waste from point of generation to final isolation. The IDB also gets major support from Program AR and is supported at lower levels by Program AP, AF, and AS. Funding for these tasks is expected to remain stable.

Assistant Secretary for Defense Programs (ASDP)

The major effort for this office is in defense waste management and may be divided into three main categories: (1) management of wastes generated at ORNL, (2) development of technology for managing low-level radioactive wastes, and (3) materials production involving administration of the national repository for ^{233}U and conversion of 100 kg of uranium from liquid to an inert solid (Table 4).

Table 4. Assistant Secretary for Defense Programs major program summary[a]

($ in millions—BA)

B&R code	Major program	FY 1983	FY 1984	FY 1985	FY 1986
AR	Defense Waste Management	24.76	22.59	24.26	27.16
GC	Verification and Control Technology	0.07	0.18	0.50	0.58
GE	Materials Production	5.65	7.45	8.34	8.78
Total		30.52	30.22	33.10	36.52
Percentage of total Laboratory funding—BA		8.6	7.6	8.2	7.9

[a]Figures include operating BA, capital equipment, and funded/budgeted construction, if any.

AR—Defense Waste Management

The major activities under this program are the operations involved in managing radioactive wastes generated at ORNL, decommissioning of surplus facilities, development of procedures and equipment to improve the safety and reliability of disposal operations, and participation in and management of the DOE Low-Level Waste Technology Development Program. The program also provides major support for the IDB and supports a task for developing applications and uses for by-product radionuclides. A new task involves the assignment to ORNL of the lead contractor role in managing DOE's Hazardous Chemical Defense Waste Management Program (see Program Initiative). Another new task is intended to foster long-term interactions of historically black colleges and universities (HBCUs) with the defense waste management programs. The total program budget is expected to increase slightly in FY 1985 and again in FY 1986 and FY 1987 because of the addition of the new tasks and increased effort in decommissioning of facilities. The program is expected to remain about constant after FY 1987.

Program Initiative. The Hazardous Chemical Defense Waste Management Program (HCDWMP) was established in November 1983 by a management agreement between Oak Ridge Operations (ORO) and the DOE Office of Defense Waste and Byproducts Management. This program covers facilities operated by DOE under the authority of the Atomic Energy Act of 1954. ORO and ORNL have been assigned responsibility as the HCDWMP lead field office and contractor, respectively. The goal of this program is to provide technology development to support ongoing generation, storage, and disposal of hazardous chemical and mixed wastes such that public health and safety are protected and ecological impact is kept to a minimum.

The central element of the strategy that guides the HCDWMP toward achievement of its goal is completion of the technology development and demonstration needed to permit full compliance of all DOE facilities with the regulations governing hazardous waste generation, storage, and disposal and, in parallel, to expedite the application of currently available or newly developed technologies and engineering techniques. The near-term components of this strategy involve definition of the magnitude and character of hazardous chemical waste (HCW) streams and inventories, the technology and facilities currently available to address them, and the regulatory and operational restraints on HCW management. This information will be used in the near term to develop detailed program plans and to recommend the application of available solutions to identified problems. Over the longer term, an integrated, DOE-wide HCW management system will be implemented, and longer term applied research for improved treatment and disposal options may be continued.

Program Construction. The Radioactive Waste Facilities Improvement project is funded and ongoing, and a Central Waste Disposal Facility is proposed as an FY 1986 line-item project. In addition, FY 1984–FY 1990 waste management General Plant Project (GPP) funding is, for the purposes of this plan, treated as proposed construction.

AR—Funded construction summary
($ in millions)

	Through FY 1983	FY 1984	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990	TEC
Radioactive Waste Facilities improvements	21.3	1.0							22.3

AR—Proposed construction summary
($ in millions)

	FY 1983	FY 1984	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990	TEC
Central Waste Disposal Facility				1.0	6.5				7.5
General Plant Projects (Waste Management)	2.0	1.8	2.4	3.5	3.2	3.2	3.2	3.2	22.5

GC—Verification and Control Technology

The Resonance Ionization Mass Spectrometry (RIMS) for Ultra-Trace Analysis task will exploit a recently developed technique utilizing laser-induced RIMS to measure isotope ratios of a variety of elements. Begun in mid FY 1984 and continuing beyond FY 1986, the effort is staff intensive, with minimum costs incurred for materials. Nuclear fuel cycle workshops will continue to be held to acquaint civil servants in various federal agencies with the nuclear fuel cycle, especially aspects relevant to nuclear nonproliferation.

GE—Materials Production

This program primarily encompasses ORNL's ^{233}U activities, which are divided into two tasks. The first is routine operation of the ^{233}U National Repository, which supplies various experimenters in the United States with the isotope, as directed by DOE through ORO. Any unused material from scrap generated by experimental studies is also recovered. Because of the decreasing interest in ^{233}U, we have been requested to look into the feasibility of placing the National Repository (Building 3019) in standby by 1990.

The second activity is the installation and operation of a facility capable of converting 1000 kg of uranium (composed mainly of the fissile isotopes of uranium) from a liquid to an inert solid. Engineering design and fabrication of the processing equipment have been completed, and installation and checkout are scheduled for completion in FY 1985. Processing is expected to begin in FY 1985, and the project is expected to be completed by FY 1987.

For several years DOE has been pooling an inventory of ^{241}Am at ORNL to meet the needs of DOE installations. An adequate inventory for the foreseeable needs has been obtained, and no additional funds are budgeted for the period FY 1985–FY 1990.

The Californium Industrial Sales/Loan Program will be transferred from Savannah River Laboratory to ORNL in FY 1986. The purpose of this program is to fabricate ^{252}Cf into neutron sources or into bulk packages for sale to industry or for loan to other government agencies.

Additional funding amounting to $2 million in FY 1984 and $2.5 million in FY 1985 and FY 1986 has been incorporated into the GE Program budget to cover a new gyrotron development task. The ORNL Fusion Program will receive this funding through the ASDP to combine with the existing program funded by the Office of Fusion Energy. The application is for isotope separation for military fuel processing. All of this funding is scheduled to be subcontracted.

Assistant Secretary for Conservation and Renewable Energy (ASCE)

ORNL activities for the ASCE encompass 11 program categories covering a diversity of conservation and renewable energy topics. In general the programs are devoting increased emphasis to

technology transfer and coordination with industrial research. Substantial increases in budget are planned for FY 1985 in ceramic technology for advanced heat engines (EE), Energy Conversion and Utilization Technologies (ECUT) materials (EG). These increases reflect both DOE program planning and ORNL assessments of research opportunities (Table 5).

Table 5. Assistant Secretary for Conservation and Renewable Energy major program summary[a]

($ in millions—BA)

B&R code	Major program	FY 1983	FY 1984	FY 1985	FY 1986
AK	Electric Energy Systems	4.56	5.00	6.53	7.03
AL	Energy Storage Systems	1.61	1.69	1.44	2.28
AM	Geothermal	0.03	0.00	0.11	0.13
CC	Geothermal Resources Development Fund	0.00	0.11	0.14	0.15
CE	Hydropower	0.60	0.05	0.00	0.00
EB	Solar Energy	3.81	6.00	7.71	8.21
EC	Building and Community Services	10.52	11.93	15.63	14.18
ED	Industrial	0.55	1.49	2.09	1.91
EE	Transportation	2.66	15.43	14.96	13.96
EF	State and Local Programs	0.60	0.45	0.63	0.60
EG	Multisector	3.50	2.53	6.10	8.60
Total		28.45	44.68	55.34	57.05
Percentage of total Laboratory funding—BA		8.0	11.3	13.8	12.3

[a]Figures include operating BA, capital equipment, and funded/budgeted construction, if any.

AK—Electric Energy Systems

Activities in the AK Program deal with power systems technology in order to investigate new concepts and develop future technology for the electric utility industry. Project technologies offer opportunities to improve the efficiency of the electric energy system, both economically and through resource conservation. Activities are currently organized into eight major task areas: dielectrics, distribution automation and control, systems research, high-voltage alternating current, high-voltage direct current, materials, electromagnetic pulse, and electric fields. Significant accomplishments during FY 1984 include the determination of the properties of solid polymer insulators, continued development of fine-grained zinc oxide varistors, and the development of a risk assessment methodology for 60-Hz high-voltage transmission lines.

In the future, tasks related to high-voltage direct current, dielectrics, electromagnetic pulse, and distribution automation will be emphasized; work in systems research and high-voltage alternating current will be deemphasized. A major project for the next few years will be the Athens Automation and Control Experiment, a large-scale distribution automation and control project being

installed on the Athens, Tennessee, Utilities Board electric distribution system. The purpose of this project is to test load control on an actual utility system and to transfer what is learned to the electric utility industry.

AL—Energy Storage Systems

In the area of thermal energy storage, ORNL has been assigned responsibility for building heating and cooling applications and for industrial applications. Program objectives have been identified; they are to develop: (1) concepts for economical heat pump thermal storage, (2) technologies for significantly increased reuse of high-temperature industrial reject heat, (3) concepts for passive solar heat storage, (4) a data base for new heat storage materials and processes, and (5) effective interactions with the private sector to determine research needs and to transfer developed technologies. In battery storage, ORNL is investigating methods for increasing the conductivity and fracture toughness of sodium-alumina in support of the development of the sodium-sulfur battery. We believe that the research of energy storage is important; the budgetary outlook, however, is uncertain.

AM—Geothermal

Our work in geothermal research now consists exclusively of examining proposed installations to ensure that the associated environmental impacts are within acceptable limits. This work is expected to remain at less than one FTE.

CC—Geothermal Resources Development Fund

Our work in the CC Program consists of examining proposed installations that have qualified for geothermal loan guarantees to ensure that environmental impacts are acceptable. This program is also expected to remain at less than one FTE.

CE—Hydropower

The purpose of our work in the CE Program is to provide technical assistance to DOE for resolution of specific environmental issues associated with small hydropower development. In FY 1985 we will monitor subcontract research on turbine-related fish mortality and complete instream flow research. Technical assistance to DOE Headquarters will continue with support provided to ORNL from the DOE Idaho Operations Office.

EB—Solar Energy

The principal activity in solar energy is the technical management of the Biomass Production Program, which consists of long-term research on the production of woody and herbaceous biomass, biofuels multiyear program planning, and environmental and economic assessment. The Solar Energy Program will assist the Biomass Energy Technology Division with the following specific tasks: (1) the development and administration of research on woody plants subjected to intensive culturing for high productivity; (2) the development and administration of research on herbaceous crop resources; (3) the complementary research on herbaceous and woody energy crops concerning environmental effects, long-term productivity, and economics; and (4) the development of multiyear program plans. The program planning task is carried out through collaboration with the other

laboratory biomass field managers at ANL, PNL, and the Solar Energy Research Institute. An increase in funding is anticipated during the next seve al years as field research gets under way on the herbaceous biomass task.

ORNL participation in other solar programs is limited to tasks in which specific expertise is available, including technical assistance on photovoltaic projects, environmental analysis for alcohol fuels, and analysis of wind energy systems. The Alcohol Financial Assistance (EB11) and Solar Applications for Buildings (EB01) programs are expected to be completed in FY 1984 and FY 1985, respectively, while the Solar Applications for Power (EB03) work is expected to continue throughout the planning cycle.

EC—Building and Community Systems

ORNL has been assigned technical management responsibility for three programs in the buildings area: Building Thermal Envelope Systems and Materials (BTESM), Building Equipment Research (BER), and Residential Conservation Service (RCS). The BTESM program was initiated in response to the need of the insulation and building industries for relevant technical information on the thermal performance of building-envelope systems and in recognition of the impact that improved thermal performance of buildings would have on energy conservation. A National Program Plan, which was developed jointly by DOE, ORNL, and the National Bureau of Standards with the assistance of industry, forms the basis for selection of research projects. A highlight of the FY 1985 program will be the procurement of equipment to enable thorough testing of roofing segments. The level of effort is expected to increase during the planning period, with increased emphasis on roofing systems and retrofit research.

The BER program seeks to conserve energy by developing improved heating and cooling systems and appliances and by making better use of space-conditioning energy in buildings. BER activities include analytical studies, development of analytical tools, and laboratory and field experiments. The major program areas are vapor-compression systems, nonazeotropic refrigerant mixtures, ground-coupled heat pumps, absorption, Stirling engine-driven systems, internal-combustion-engine-driven heat pumps, and advanced insulation. Funding is expected to remain constant during the planning period.

The RCS program consists of providing DOE with the technical management functions for effective implementation of the congressionally mandated building-retrofit program. As implementation activities are completed, the emphasis is shifting to program evaluation and research on improved retrofit techniques. ORNL participation in RCS is expected to phase out in FY 1986.

ED—Industrial

ORNL is responsible for two projects in Waste Energy Reduction (ED01). The first of these, Materials for Waste Heat Utilization, provides materials technology support to the Waste Energy Utilization Branch and its contractors in support of recuperator development and in developing improved ceramic technologies. In the second project, Chemical Heat Pumps, the objective is to develop chemical heat pump technology for recovering industrial and process waste heat. A comprehensive evaluation of potential chemical heat pump technologies was completed during FY 1984.

Under Industrial Process Efficiency (ED02) a study of brittle fracture in amorphous metals is under way with intended application for power transformers and motors. This study is included

within the general framework of research for the Division of Electric Energy Systems. Preliminary results are encouraging with respect to producing a substantially more ductile material. The level of effort for the Office of Industrial Programs is expected to remain constant during the planning period.

EE—Transportation

Assignments for the Office of Vehicle and Engine Research and Development include the development of ceramic technology for advanced automotive heat engines, the analysis of transportation data related to energy use, and technical management of the Alternative Fuels Utilization Programs. Operating support for the ceramic technology program is expected to undergo substantial increases in size during the next four years, in accord with the resource requirements identified in the program plan, "Ceramic Technology for Advanced Heat Engines." The approach includes determining the mechanisms controlling reliability, improving processes for fabricating ceramics, and testing ceramic materials in simulated engine environments to confirm reliability. Research will be closely coordinated, with complementary ceramics tasks funded by other DOE offices, NASA, DOD, and industry.

A new facility, the HTML, is scheduled for completion and occupancy in FY 1987. This facility will house laboratories and unique special equipment for high-temperature materials research by ORNL staff and by researchers from industry, universities, and other government laboratories.

EE-Funded construction summary

($ in millions)

	FY 1983	FY 1984	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990	TEC
HTML	1.0	9.0	6.6	2.7					19.3

EF—State and Local Programs

ORNL assignments in State and Local Programs are to assist DOE in the evaluation of the effectiveness of several programs, including the Energy Extension Service and the Weatherization Assistance Program. Continuation of this work is predicated on continued congressional funding for State and Local Programs.

EG—Multisector

ORNL has been assigned technical management responsibility for the Materials Project and participates in the Tribology (wear and friction) Project—both in the ECUT program. Under the Materials Project, research is being conducted on high-temperature materials, lightweight materials, and materials properties modeling. Under the Tribology Project, the principal work element is friction and wear of ceramics. Substantial increases in activity are expected for the Materials Project during the next two years as a result of the large number of successful developments by ORNL and several subcontractors.

Two additional projects within EG are development of microemulsion fuels and the evaluation of results obtained through the Energy Related Inventions Program (ERIP). Continuation of the latter project is expected for as long as Congress supports ERIP. A new research project in biocatalysis development is proposed for initiation in FY 1985.

Assistant Secretary for Fossil Energy (ASFE)

ORNL programs for the ASFE cover three major areas: coal, petroleum, and alternate fuels. The Coal Program (AA) is, however, the primary focus of the Laboratory's fossil energy activities (Table 6). The coal budget is anticipated to remain approximately constant, with primary emphasis on materials, environment, and health.

Table 6. Assistant Secretary for Fossil Energy major program summary[a]

($ in millions—BA)

B&R code	Major program	FY 1983	FY 1984	FY 1985	FY 1986
AA	Coal	8.97	9.52	11.02	11.94
AB	Gas	0.12	0.00	0.18	0.17
AC	Petroleum	0.005	0.00	0.00	0.00
CH	Alternate Fuels Production	0.06	0.19	0.00	0.00
Total		9.15	9.71	11.20	12.11
Percentage of total Laboratory funding—BA		2.6	2.5	2.8	2.6

[a]Figures include operating BA, capital equipment, and funded/budgeted construction, if any.

AA—Coal

ORNL's work in the Coal Program involves several areas of activity; however, the principal emphasis is on materials R&D and on environmental and health-related R&D. The materials R&D includes management (with ORO) of the National Fossil Energy Materials Program and is directed toward development, joining, mechanical properties, corrosion and erosion, and wear of alloys; mechanical properties and corrosion of refractories; and powder synthesis, fabrication, characterization, and testing of ceramics. The environment and health R&D includes work within the Fossil Energy Technology Environmental Program and is directed toward characterization and bioactivity assay of coal liquids, assessment of environmental control technology, treatment of coal conversion wastewaters and development of disposal methods for resulting sludges, characterization of fate and effects of coal liquids on aquatic and terrestrial organisms, industrial hygiene studies, disposal methods for solid wastes resulting from coal use, and improving current understanding of acid precipitation. We would like to see the environmental health and safety area grow to encompass a broader program of sufficient strength to impact priority national programs. However, the present funding projections do not include such growth.

Work is also carried out in a broad range of individual projects, which include work on computer modeling and simulation; evaluation of coal conversion technologies including bioconversion concepts; and development of automated methods for analysis of coal liquids.

AB—Gas

Funding in the Gas Program covers economic and technical evaluations of processes. Future funding is anticipated at a level of about one FTE.

AC—Petroleum

Petroleum Program work in FY 1983 represented a closeout of prior research on amphiphilic compounds for use in the micellar flood approach to enhanced oil recovery. Further funding in this area is not currently anticipated.

CH—Alternate Fuels Production

Work in the Alternate Fuels Production Program in FY 1984 represented a closeout of funding covering modeling of coal gasification process technologies. Further funding in this area is not currently anticipated.

Energy Information Administration (EIA)

ORNL provides research and management support to EIA. ORNL programs in support of EIA draw upon multidisciplinary teams from both inside and outside the Laboratory. The work consists of analysis, assessment, evaluation, and model development research for the four principal offices within EIA. During FY 1984 the fraction of work conducted by in-house staff increased relative to that done under subcontract. Also, the overall level of effort declined significantly from previous years. These trends are expected to continue. A major effort of analyzing the viability of the U.S. uranium mining and milling industry was initiated in Program TA in FY 1983 and is expected to continue for at least two years (Table 7).

Table 7. Energy Information Administration major program summary[a]

($ in millions—BA)

B&R code	Major program	FY 1983	FY 1984	FY 1985	FY 1986
TA[b]	Collection Production and Analysis	0.50	1.05	2.04	1.61
TB	Program Services	0.00	0.19	0.00	0.00
Total		0.50	1.24	2.04	1.61
Percentage of total Laboratory funding—BA		0.1	0.3	0.5	0.3

[a]Figures include operating BA, capital equipment, and funded/budgeted construction, if any.

[b]Major portions of FY 1983 and FY 1984 costs were supported by previous year funding obligations.

Assistant Secretary for Policy, Safety, and Environment (ASPSE)

Most of the work ORNL does for the new ASPSE has been transferred from the former office of the Assistant Secretary for Environmental Protection, Safety, and Emergency Preparedness. The new office also has responsibility for some of the work of the former Office of Policy, Planning and Analysis. ORNL tasks include development of environmental policy assessment methodologies and models, application of these to analysis of proposed and existing environmental legislation and regulation, and planning and assessment of technologies for dealing with radiological emergencies. Activity at ORNL is funded only under the HA01 Program (Table 8).

Table 8. Assistant Secretary for Policy, Safety, and Environment major program summary[a]

($ in millions—BA)

B&R code	Major program	FY 1983	FY 1984	FY 1985	FY 1986
HA01	Overview and Assessment	3.61	1.89	1.78	3.03
Percentage of total Laboratory funding—BA		1.0	0.5	0.4	0.7

[a]Figures include operating BA, capital equipment, and funded/budgeted construction, if any.

HA01—Overview and Assessment

Significant shifts have occurred in programs for environmental policy studies and analysis and environmental technical assistance to the Office of Environmental Compliance (OEC). Technical assistance to OEC (initiated in FY 1979) is expected to increase in FY 1985. ORNL will continue National Environmental Protection Act (NEPA) support and develop a system for tracking and analyzing DOE federal regulatory initiatives. For six years ORNL has supported the Office of Environmental Analysis in DOE in the development of energy resource assessment models and in the provision of background research for various energy policy issues. This support will continue with increased attention to acidic deposition issues. The sponsors of the Emergency Technology Program (ETP) plan to increase the research component of the program. Under the ETP, ORNL personnel review and assist in emergency planning and preparedness for environmental protection and public safety.

Funding at the level of $330 thousand for the Radiological Survey program, or UMTRAP, will be transferred from HA01 to AH under the ASNE.

Federal Energy Regulatory Commission (FERC)

ORNL efforts for FERC have increased over the past year. In addition to the Susitna hydroelectric project EIS begun last year, ORNL initiated work for the Office of Electric Power (OEP) to assess the environmental impacts of small hydroelectric development on the upper San Joaquin River Basin in California. Studies of this type are expected to continue over the next few years because OEP has a large number of applications for small hydroelectric projects [≤5 MW(e)] on

12 river basins on the west and east coasts of the United States. However, overall efforts for FERC are expected to remain fairly stable at the FY 1984 level over the planning cycle (Table 9).

Table 9. Federal Energy Regulatory Commission major program summary[a]

($ in millions—BA)

B&R code	Major program	FY 1983	FY 1984	FY 1985	FY 1986
VP	Other Expenses	0.33	0.52	0.70	0.75
Percentage of total Laboratory funding—BA		0.1	0.1	0.2	0.2

[a]Figures include operating BA, capital equipment, and funded/budgeted construction, if any.

Assistant Secretary for International Affairs and Energy Emergencies (ASIAEE)

For the ASIAEE we are conducting assessments of industry vulnerability to emergencies and providing technical assistance in policy and evaluation to support the DOE role in emergency test exercises and various emergency preparedness issues. Funding in FY 1983–FY 1986 is from previously obligated budgets (Table 10).

Table 10. Assistant Secretary for International Affairs and Energy Emergencies major program summary

($ in millions—BA)

B&R code	Major program	FY 1983	FY 1984	FY 1985	FY 1986
UB	Utility Programs and Regulatory Intervention	0.00	0.00	0.00	0.00
UE	Fuels Regulation	0.00	0.00	0.00	0.00
Percentage of total Laboratory funding—BA		0.0	0.0	0.0	0.0

Assistant Secretary for Management and Administration (ASMA)

ORNL does a small amount of work for ASMA under two B&R codes, LA and WB (Table 11). The LA category covers activity related to the DOE Office of Technical and Scientific Information. This funding is expected to increase modestly throughout the planning cycle. No ORNL personnel are supported by Program LA. The WB Program covers an In-House Energy

Management activity. Energy Conservation GPP (listed in Table 28), which is associated with WB, will continue throughout the planning cycle.

Table 11. Assistant Secretary for Management and Administration major program summary[a]

($ in millions—BA)

B&R code	Major program	FY 1983	FY 1984	FY 1985	FY 1986
LA	Technical Information Services	0.96	1.10	1.16	1.12
WB	In-House Energy Management	0.00	0.13	0.10	0.10
Total		0.96	1.23	1.26	1.22
Percentage of total Laboratory funding—BA		0.2	0.3	0.3	0.3

[a]Figures include operating BA, capital equipment, and funded/budgeted construction, if any.

Work for Other DOE Installations

Roughly $12 million (3%) of ORNL's FY 1984 Operating and Capital equipment BA is categorized as Work for Other DOE Contractors and Operations Offices. The distribution of these funds by major ORNL program area is given in Table 12.

Table 12. Other Department of Energy contractors and Operations Offices[a] major program summary

($ in millions—BA)

Program area	FY 1983	FY 1984	FY 1985	FY 1986
Fission	6.90	9.76	8.67	8.69
Biomedical and Environmental	0.41	0.67	0.28	0.25
Basic Physical Sciences	0.94	1.41	0.35	0.36
Fusion	0.10	0.03	0.04	0.01
Fossil	2.82	0.91	0.77	0.72
Conservation and Renewable Energy	1.56	1.18	1.10	1.10
Other	0.16	0.17	0.07	0.07
Total	12.88	15.13	11.29	11.21
Percentage of total Laboratory funding—BA	3.6	3.8	2.8	2.4

[a]Figures include operating BA, capital equipment, and funded/budgeted construction, if any.

In the fission area, ORNL is continuing to supply technical assistance to several DOE contractors for a variety of projects. For example, personnel are being used (1) to provide facilities and expertise for irradiating reduced-enrichment fuel elements for ANL, (2) to seek potential solutions for the disposal of sludges by use of concrete and grouting techniques at HEDL, (3) to develop severe accident boiling-water reactor (BWR) analysis codes for SNL, and (4) to review and evaluate the Safety Analysis Report for packaging of dry cask storage of spent nuclear fuel for Idaho Operations Office, and (5) to contribute to the Gas Centrifuge Enrichment Program and Atomic Vapor Laser Isotope Separation program at ORGDP. Continued funding in such programs is uncertain but is expected to decrease in FY 1985 and then remain constant.

In the Fossil Energy Program, work funded by other DOE contractors and by Energy Technology Centers includes one staff person on assignment in India for fluidized-bed combustion R&D, support of environmental and health assessment studies on direct liquefaction technology, health risk assessment, and technical support and an environmental analysis for the Strategic Petroleum Reserve.

In the conservation area, work consists of a number (roughly 12) of small projects closely related to our major responsibilities for the ASCE. Although the individual projects will change, the level of effort is expected to remain about the same through the planning cycle.

Work for Others

Nuclear Regulatory Commission (NRC)

NRC is the largest single non-DOE supporter of ORNL activities. Of ORNL's FY 1984 operating and capital equipment budget authorization, about 8% comes from NRC, which amounts to over 38% of all the Laboratory's Work for Others (WFO).

Through its various programs at ORNL, NRC receives research and technical support in areas in which the Laboratory has demonstrated significant expertise. These areas include structural analysis, materials evaluation, fission product behavior, accident sequence analysis, advanced instrumentation and diagnostics, human factors, reliability and operating data analysis, integrated risk assessment, and radiation dose and health effects. Based on the current NRC budget projections, ORNL efforts are expected to remain essentially constant after FY 1985 (Table 13).

ORNL activities for NRC are divided into the following six categories, reflecting work for the different offices funding the efforts.

Nuclear Reactor Regulation

As the Nuclear Reactor Regulation activity's major task, ORNL assists in administering operator examinations for the Operator Licensing Branch of NRC. Also, the Laboratory provides technical consultation and specialized measurements for test methods to detect anomalous behavior in LWRs.

Administration

The Laboratory furnishes technical support for the administration of NRC operations through the Radiation Shielding Information Center and the Technical Data Management Center. Both programs are well established and are expected to remain stable through FY 1990.

Table 13. Nuclear Regulatory Commission program resource summary[a]

($ in millions—BA)

Major program office	FY 1983	FY 1984	FY 1985	FY 1986
Nuclear Reactor Regulation	2.62	2.26	2.08	2.07
Administration	0.43	0.44	0.46	0.49
Nuclear Materials Safety and Safeguards	2.66	2.25	2.50	2.70
Nuclear Regulatory Research	22.08	22.93	22.02	19.47
Analysis and Evaluation of Operational Data	1.51	1.97	1.71	1.71
Other offices	0.69	1.49	1.07	1.28
Total	30.00	31.34	29.84	27.72
Percentage of total Laboratory funding—BA	8.5	7.9	7.4	6.0

[a]Figures include operating BA and capital equipment.

Nuclear Materials Safety and Safeguards

Efforts in the Nuclear Materials Safety and Safeguards area include shipping-cask analysis, environmental assessments of fuel cycle facilities, technical support and laboratory-oriented evaluation in geochemical areas related to the licensing of radioactive waste repositories, and survey of metabolic data appropriate to high-level waste dosimetry. Increased interest in environmental assessment tasks and waste management is anticipated.

Nuclear Regulatory Research

The Office of Nuclear Regulatory Research supports the largest NRC program at ORNL. Relatively large efforts are under way for obtaining an improved data base for the the behavior of fission products and aerosols in severe reactor accident situations and for the long-term behavior of reactor pressure vessels. The fission product studies will have significant impact on the development of a Commission Policy Statement on severe reactor accidents. With the issuance of this policy statement, which is expected during FY 1985, some decrease in fission product research is likely. In contrast, there is an increasing interest in extending the operational life of existing power plants beyond their original design. This trend is expected to result in increased research in aging characteristics of plant components. A unique experimental capability now being utilized in the Pressurized Thermal Shock Facility of the Heavy-Section Steel Technology Program provides confirmation of analytical predictions on behavior of thick-walled pressure vessels under combined thermal and pressure loadings.

Overall, a slight decrease in ORNL effort is anticipated beyond FY 1985, and changes in research emphasis are expected.

Analysis and Evaluation of Operational Data (AEOD)

About two-thirds of the funds from the AEOD support the Sequence Coding and Search System (SCSS), which is performed by the Nuclear Operations Analysis Center. The SCSS task involves the development and operation of a new system for increasing the usefulness of the descriptive text contained in Licensee Event Reports. Other activities include the operation and maintenance of both a nonreactor data file and a foreign reactor events file (proprietary). In addition, AEOD has recently established a construction deficiency report system that is to be a major data base for use by NRC. Funding is expected to remain stable.

Other Offices

The Laboratory provides technical assistance in the conduct of inventory verification, analysis of special nuclear materials samples, preparation of site-specific material standards, and review of environmental assessments and operating procedures changes for the regional offices. A slight increase in funding is anticipated.

Department of Defense (DOD)

ORNL performs work for four primary branches of DOD—the Army, Navy, Air Force, and Defense Nuclear Agency—as well as for joint agencies of DOD. This work is projected to grow to a significant fraction of the Laboratory's total budget in this planning cycle (Table 14). A significant amount of ORNL's technical expertise can be readily applied to defense research needs. Efforts are under way to develop expanded programs with DOD in areas that complement the primary missions of ORNL and simultaneously satisfy the DOD needs. Examples include power systems, materials, structures, heat transfer, data involving lasers, data analysis, data systems R&D, and interaction of radiation with microelectronic circuitry. ORNL is also proposing a new initiative on the Strategic National Defense System.

Table 14. Department of Defense program resource summary[a]

($ in millions—BA)

Major program office	FY 1983	FY 1984	FY 1985	FY 1986
Army	2.82	4.97	5.78	6.03
Navy	3.70	15.15	22.00	24.00
Air Force	0.70	1.63	3.96	1.65
Defense Nuclear and Other	0.49	0.53	0.52	0.53
Total	7.71	22.28	32.26	32.21
Percentage of total Laboratory funding—BA	2.2	5.6	8.0	6.9

[a]Figures include operating BA and capital equipment.

Army

The ORNL research for the Army primarily involves physical, chemical, and toxicological characterization of chemicals (and their degradation products) of interest to the Army. Examples include diesel fuel, synthetic and alternative fuels, fog oil, dyes, phosphorus formulations, explosives, and sorbent compounds. Funding for Army programs at ORNL increased from $1.6 million in FY 1981 to $2.8 million in FY 1983, with further increases expected in the coming years. Studies of the adverse health and environmental effects of diesel fuel and military obscurants will be completed in FY 1984, but we anticipate receiving new work on other substances in the future. The preparation of data-base assessments related to munitions production plant wastes will continue, with significant growth in the development of water criteria reports on several specific waste products to be identified by the Army.

ORNL also continued activities in data systems architecture, management, and analysis for the Army in FY 1984. All of this work focuses on helping the Army integrate state-of-the-art hardware and software data systems into key programs. Work continues for the Military Traffic Management Command, Army Civilian Personnel Center, and Army Materiel Command. Work is also planned to provide transportation logistics support to the Armed Forces Command for mobilization of active and reserve units nationwide. ORNL has been able to successfully research methods and techniques that allow these agencies to keep pace with rapidly developing technology vital to effective management, decision making, and strategic planning. Army support of design research, prototype development, data modeling, systems planning and integration, and data system implementation will contribute to the advancement of scientific knowledge related to large-scale and/or complex computer data systems. The Army will continue to support data systems R&D activities at ORNL as the demands for effective nontactical expert and intelligent systems continue to grow.

Other ORNL efforts for the Army include studying the feasibility of using Army high-volume hazardous waste streams as supplementary feedstocks in industrial boilers, validating energy and cost savings of Energy Conservation Investment Program projects, and developing a technology transfer and inquiry response system to assist facility engineers with energy conservation issues.

Navy

For the Navy, ORNL conducts R&D and performs analyses related to data systems improvement, instrumentation, materials, fuel supply and use, energy conservation, and waste disposal. These activities help to expand the frontiers of knowledge in areas that can benefit DOE programs as well as provide needed assistance to the Navy. This work supports a number of Navy commands, offices, research centers, and field activities. ORNL may be asked to play a major instrumentation R&D role for the David Taylor Naval Ship R&D Center, but this possibility is not reflected in the budget numbers (Table 14).

Over the planning period, the major emphases are expected to be (1) instrumentation and systems engineering and (2) data systems research, development, and technical assistance especially in the areas of marine telecommunications and computer-aided instruction. The latter activity has resulted in the establishment of a data systems resource management laboratory at ORNL, to be used for experimentation with advanced tools and equipment and for prototype system design efforts.

The growing ORNL work for the Navy has been fortuitous in that it uses staff skills in areas where other funding is declining. It also provides an opportunity to do R&D in advanced

information and knowledge processing that will have useful applications in many of the central areas of ORNL work.

R&D being supported by the Navy continues to include concept and methodology development and original research on expert systems, decision support systems, knowledge acquisition, and representation. R&D on data system design, data modeling, and information architecture to improve the quality and responsiveness of technical information systems and models to match increasing demands represents key aspects of technology development in the area. Combining data-base management methodology with predictive systems analysis techniques is an integral part of Navy technical support activities.

Air Force

ORNL carries out work in a variety of areas for the Air Force. Major activities include the development of new mathematical algorithms appropriate to pipeline, vector, and array processors; the study of swift atom-solid collisions; an assessment of potential hazardous waste sites; preparation of radioluminescent lights for remote airfields; and the development of selection criteria for insulating materials. Regional analyses to determine biophysical regions of influence around Air Force bases will continue in FY 1985. ORNL will also provide technical support to the Installation Restoration Program in developing priorities for sites for remedial actions related to hazardous wastes. Use of the HPRR for radiation dosimetry development and for training of Air Force personnel in dosimetry techniques is a projected new activity. ORNL will conduct R&D related to advanced-knowledge processing and expert system design and development as well as provide broad computer science, data analysis, and management support to the Air Force Command and Control Information Systems Management Office. Of immediate importance are the specific areas of data systems architecture and systems integration, data modeling, and data-base design for a multitude of configurations. Technical assistance and R&D will support Air Force responsibility to evaluate alternative hardware and software configurations to support Major Commands' systems responsibilities beyond the 1980s. The systems engineering research and support will consist of research and analysis, cost-benefit analysis, design specifications, configuration management, data management, benchmarking of on-line systems, data validation, system verification and validation, system implementation, technical writing, instruction and training, and automated data processing (ADP) systems site planning and operations, and telecommunications.

Defense Nuclear Agency

The major activities in this area are associated with the Radiation Shielding Information Center and with radiation transport studies. Analytical methods and related nuclear data sets for calculating the transport of weapons radiations are developed, evaluated, and disseminated. In addition, specific design-support analyses for difficult problems in radiation shielding are provided. These activities are projected to continue at essentially constant levels.

Department of the Interior (DOI)

An interagency agreement was initiated in September 1983 to provide the Bureau of Land Management of DOI with technical assistance and research support in the areas of natural resource management; analysis and assessment; and data system design, development, and implementation.

Under this agreement, ORNL support for DOI will not increase during the planning period from historic levels. ORNL will support the Office of the Secretary in fulfilling the DOI responsibilities under the Comprehensive Environmental Restoration, Compensation, and Liability Act, including support for damage assessments, regulations, monitoring and mitigations development. In addition, the Laboratory continues to provide support for the Office of Surface Mining, the U.S. Geological Survey, and the Minerals Management Service, at a low level of effort; and from time to time it assists DOI in preparing environmental compliance documents required under NEPA (Table 15).

Table 15. Department of the Interior program resource summary

($ in millions—BA)

Major program	FY 1983	FY 1984	FY 1985	FY 1986
Department of the Interior	1.20	0.55	1.35	1.63

Department of Health and Human Services (DHHS)

DHHS supports research in carcinogenesis, genetics, and toxicology. Its funding is expected to remain reasonably constant over the next five years. The various branches of DHHS supporting our work include the National Cancer Institute (NCI); the National Institute of Environmental Health Sciences; the National Heart, Lung, and Blood Institute; the National Institute of General Medical Sciences; the National Institute of Child Health and Human Development; the National Institute on Drug Abuse; the Food and Drug Administration (FDA); the National Library of Medicine (NLM); and the National Toxicology Program (NTP). We expect an expanded effort in radiation carcinogenesis research supported by NCI and a small pilot effort in the data systems area. For FDA, NLM, and NTP, we are developing nationally and internationally available data bases in the areas of genetic, reproductive, and general toxicology. We expect additional funding in FY 1984 from the DHHS portion of the super-fund money for expansion of our toxicology data bases. This effort is designed to assist in assessing the potential human and environmental health risks of hazardous waste cleanup efforts (Table 16).

Table 16. Department of Health and Human Services program resource summary

($ in millions—BA)

Major program	FY 1983	FY 1984	FY 1985	FY 1986
Department of Health and Human Services	5.01	5.84	7.00	7.00

Environmental Protection Agency (EPA)

Overall, our EPA program will be maintained at about the same level of effort throughout the planning cycle as in FY 1983, with fluctuations in specific program areas. Our work for EPA

addresses numerous health and environmental problems and issues—particularly research into the toxic effects of pollutants associated with energy-production processes and waste disposal. Health risk analysis and epidemiological studies will continue to be important components of this work. Quantitative mutagenicity testing is proceeding but at a lower level of effort than in previous years. Environmental risk assessment and waste leachate characterization activities are expected to continue at present levels. Acidic precipitation research activities are increasing, with major emphasis on the effects of acidic precipation on agricultural and natural systems and on ion mobility in soils, and integrated assessment support to the National Acidic Precipitation Assessment Program. ORNL also has the lead role for EPA in planning and organizing the research in the Terrestrial Effects of Acidic Precipitation Program. New research has been initiated in environmental toxicology to evaluate the utility of aquatic ecosystem models for predicting the ecological effects of toxicants. ORNL has been assisting the Environmental Results Branch of the Office of Management Systems and Evaluation in EPA to develop computer analysis capabilities that will allow EPA to better formulate environmental regulatory policy.

Data-base development activities for EPA have decreased in 1983 and 1984; however, significant portions of the Environmental Mutagens, Teratogens, and Carcinogens data-base development will continue to be performed in support of EPA's Office of Toxic Substances programs. Increases are expected in 1985 in data management and the preparation of criteria standards reports in support of the Office of Pesticides' regulatory activities (Table 17).

Table 17. Environmental Protection Agency program resource summary[a]

($ in millions—BA)

Major program	FY 1983	FY 1984	FY 1985	FY 1986
Environmental Protection Agency	4.70	4.26	4.40	5.00

[a]Figures include operating BA and capital equipment.

National Science Foundation (NSF)

NSF, in conjunction with DOE, continues to provide support for the National Center for Small Angle Scattering Research. This is a national user-dedicated facility that makes two main instruments available to users: the NSF-constructed, 30-m, small-angle neutron-scattering instrument and the DOE-constructed, 10-m, small-angle X-ray scattering camera. These instruments are intended to provide state-of-the-art capability for investigating structures of condensed matter on the scale of tens to hundreds of angstroms. They are used extensively for materials science research, as well as research in biology, chemistry, polymer science, and diffraction physics.

Because of our unique position as a leader in systems and theoretical ecology, ORNL plays a strong role in these fields and works closely with various universities. NSF recognizes ORNL's leadership in ecosystem research and provides support for the study of material spiraling in stream ecosystems as an approach for the analysis of the transport and retention of nutrients and organic matter, for the study of the terrestrial biosphere's role in the global carbon cycle, and for the devel-

opment and application of new methodologies for analyzing ecosystem-level problems. A slight increase in funds for our biotechnology program is also expected beginning FY 1985 (Table 18).

Table 18. National Science Foundation program resource summary

($ in millions—BA)

Major program	FY 1983	FY 1984	FY 1985	FY 1986
National Science Foundation	1.95	1.83	2.25	2.54

Tennessee Valley Authority (TVA)

ORNL work for TVA has declined from levels of prior years. The largest fraction of current support is in the area of coal preparation and other fossil-energy applications. This work is followed by conservation evaluation work and then by a variety of miscellaneous analytical and testing services. Other research support is provided to understand the effects of TVA operations on the ecology of reservoirs (Table 19).

Table 19. Tennessee Valley Authority program resource summary

($ in millions—BA)

Major program	FY 1983	FY 1984	FY 1985	FY 1986
Tennessee Valley Authority	0.36	0.27	0.58	0.67

Federal Emergency Management Agency (FEMA)

ORNL programs for FEMA include a range of research, development, and technical assistance in support of national preparedness for major emergencies, including but not limited to nuclear attack. During FY 1984, our work expanded to cover a wide range of analysis and assessment activities for FEMA's National Preparedness Directorate. Areas of analytical support now include earth-covered housing for fallout protection, especially shelter cost reduction; forecasting radiation levels from fallout caused by multiple nuclear detonations; developing concepts and handbooks to strengthen the national radiological defense system; assistance with the use of computer graphics; economic analyses of preparedness options; evacuation planning; analyses of postdisaster recovery; technical bases for a strategic food reserve; and integrated assessments of the current state of knowledge about areas of FEMA responsibility. ORNL also provides engineering assistance relative to radiation detection and protection, such as the development of improved dosimeter chargers, instrumentation, assistance in hardening civil defense installations against electromagnetic pulse (EMP) effects, and storing certain radiological materials. These programs are expected to continue at a stable level (Table 20).

Table 20. Federal Emergency Management Agency program resource summary

($ in millions—BA)

Major program	FY 1983	FY 1984	FY 1985	FY 1986
Federal Emergency Management Agency	1.96	2.62	3.55	3.35

[a]Figures include operating BA and capital equipment.

Synthetic Fuels Corporation (SFC)

ORNL assisted SFC in planning environmental and socioeconomic studies as part of the work on the Recommended Comprehensive Strategy Report to Congress. These studies were to determine regional carrying and assimilation capabilities and to analyze regional environmental factors related to synthetic fuels. Future work for SFC is dependent upon the needs of SFC. No work is currently ongoing or planned at ORNL.

Department of Transportation (DOT)

ORNL's Conservation and Renewable Energy Program performs work on several small projects for DOT, which complement and support DOE programs. The work includes studies of vehicle travel classification, laboratory testing of fuel consumption and emissions as a function of fuel flow and manifold pressure, and analysis and modeling of traffic data. ORNL expects to continue to provide technical support to DOT for research related to transportation energy issues, traffic engineering and safety, and technology transfer through the planning cycle (Table 21).

Table 21. Department of Transportation program resource summary

($ in millions—BA)

Major program	FY 1983	FY 1984	FY 1985	FY 1986
Department of Transportation	0.30	0.31	0.40	0.53

Department of Justice (DOJ)

Research support for data systems activities by DOJ continued in FY 1984. While most of our work was funded by the Immigration and Naturalization Service (INS), new work was initiated in FY 1984 for data systems and energy data analysis for the Antitrust Division. The scope of INS work will expand in FY 1985 and FY 1986 to include instrumentation R&D for remote-sensing, alarming, and logging systems; electronic signal processing; and development of analytical models for predicting immigration trends and patterns as well as population studies. Simulation modeling and additional analysis and assessment may be included as this program continues to evolve, par-

ticularly for the Antitrust Division on energy data analysis and assessment. It is possible that ORNL may be asked to play a major data systems role if the proposed Immigration Reform and Control Act becomes law, but this possibility is not reflected in the budget numbers (Table 22).

Table 22. Immigration and Naturalization Service program resource summary

($ in millions—BA)

Major program	FY 1983	FY 1984	FY 1985	FY 1986
Immigration and Naturalization Service	0.35	2.55	1.40	0.85

Other Federal Agencies

ORNL also provides technical support to a variety of other federal agencies. The Consumer Product Safety Commission, NASA, the National Oceanic and Atmospheric Administration, and the Department of Agriculture all support small amounts of life sciences research totaling approximately $1.7 million in FY 1984. Some $365 thousand in support for FY 1984 is also coming from the U.S. Department of State for work performed for the Agency for International Development (AID) and IAEA, with an expanded Laboratory role in support of the energy planning role of AID expected in FY 1985 and FY 1986. Energy Conservation Program Evaluation and Energy Demand analysis is continuing for the Bonneville Power Administration. Data systems R&D is also being conducted at a low level for the departments of Labor and Education. This has taken the form of consulting support by ORNL staff and, while expected to continue for these and possibly other agencies, it is not expected to grow or develop beyond application of our unique skills where temporary support is requested (Table 23).

Table 23. Other Federal Agencies program resource summary[a]

($ in millions—BA)

Major program	FY 1983	FY 1984	FY 1985	FY 1986
Other Federal Agencies	3.48	3.65	5.45	2.59

[a]Figures include operating BA and capital equipment.

Nonfederal Organizations

Electric Power Research Institute (EPRI)

Research sponsored by EPRI addresses critical national issues related to electric power generation. Major efforts in this area are directed at understanding the processes and mechanisms by which acidic deposition of energy-related pollutants impact nutrient cycling and sulfur and nitrogen

dynamics of forest ecosystems; discriminating the relative importance and effects of wet and dry deposition of acidic substances in both forest and agricultural systems; measuring submicron aerosol deposition rates in forest canopies; and characterizing the role of potentially toxic aluminum mobilization in streams. Also included are projects on the effects of acidic deposition on fisheries and lakes, studies of the role of cooling towers in the ecology of Legionnaires' disease, energy demand analysis, evaluation of energy conservation programs, and research on instrumentation and controls related to improved safety and availability of LWR systems. The Laboratory expects to continue these or other programs for EPRI and anticipates that this funding will expand during the course of the planning cycle. A proposal has been approved that will provide a lead role for ORNL in EPRI's new major thrust on the effects of acid deposition on forest soils (Table 24).

Table 24. Electric Power Research Institute program resource summary[a]

($ in millions—BA)

Major program	FY 1983	FY 1984	FY 1985	FY 1986
Electric Power Research Institute	2.19	1.88	2.88	2.73

[a]Figures include operating BA and capital equipment.

Other Nonfederal Organizations

ORNL's unique expertise in many research areas results in a number of small or short-term projects being performed for many different nonfederal organizations. Such activities are beneficial to, and do not interfere with, DOE-sponsored work. Currently nonfederal sponsors include such entities as the United Kingdom's Atomic Energy Agency; JAERI; the Canadian Atomic Energy Commission; the universities of Tennessee, Mississippi, Maryland, and Wyoming; the states of California, Maryland, and Alaska; the Gas Research Institute; Metropolitan Edison/General Public Utility; the Florida Institute of Phosphate Research; Gulf Oil; General Electric; and the Technology for Energy Corporation. As a new activity in FY 1984, the ORNL fusion program is receiving funds from the JET program in Europe for conducting a beryllium-limiter experiment in the ISX-B tokamak. The total amount of funding that will be derived from miscellaneous nonfederal sources for FY 1984 is estimated currently at about $6.4 million (Table 25).

Table 25. Miscellaneous nonfederal program resource summary

($ in millions—BA)

Major program	FY 1983	FY 1984	FY 1985	FY 1986
Other Nonfederal Organizations	1.01	4.41	4.30	3.82

Site and Facilities

SITE AND FACILITIES

Site Development

Program Impact

The mid and late 1980s are projected to be a period of reasonably stable funding and resource requirements. A slight increase in overall staff levels is projected to be required to meet shifting programmatic priorities. Basic Physical Sciences, a major program area at Oak Ridge National Laboratory (ORNL), is expected to increase moderately. The Assessments and Analysis area projects a significant increase; but this program area is small, and impact on overall staff needs will not be great. Other program areas are more stable, with only minor changes expected. Of particular significance is a projected modest regrowth in the biomedical and environmental research area.

Projected program trends suggest that ORNL will continue to require most of its existing facilities for the foreseeable future. While consolidation of some activities to better, more adequate facilities has begun and will continue, it will not eliminate numerous long-standing facilities problems. Also, the overall age of the Laboratory facilities (75% are greater than 30 years old) will dictate an aggressive long-term restoration/replacement program.

The Laboratory's utility systems and general support buildings will constitute a major portion of restoration/replacement requirements. In addition, the major programmatic activities located at Y-12 will need varying degrees of facilities restoration or replacement. The growth projected in various programmatic activities, especially Basic Physical Sciences, will require several new facilities to enhance our research capabilities and overcome some significant existing facilities deficiencies.

Beyond the requirements to respond to the ongoing operational needs of the Laboratory and programmatic change is the currently evolving requirement to respond to newly developing environmental protection criteria. Because these criteria affect both new activities and abatement solutions to the problems associated with past practices, the full scope (which is still being developed) could have broad implications for the Laboratory. The initial impact of the criteria has been to further constrain the overhead of the Laboratory and the already overtaxed General Plant Project (GPP) and General Plant Equipment (GPE) budgets and to divert the Multiprogram General Purpose Facilities (MGPF) support. A proposed ORNL Environmental Restoration and Upgrade line items project to address the situation is described in Facilities Plans: 1985–1990.

Site Development Plan (SDP)

The ORNL SDP was approved by the Department of Energy (DOE) on May 1, 1984. The data contained in the SDP were based on the *FY 1984–FY 1989 Institutional Plan.* Changing program requirements and priorities during the past year have necessitated numerous minor modifications to be made to the SDP data. Future updates of the SDP will coincide with the issuance of the Institutional Plan so that both documents will contain consistent information.

The main thrust of the SDP throughout the planning period is to maintain existing adequate facilities, upgrade currently inadequate facilities through both rehabilitation and selected replacement, and provide additional facilities when required to meet new initiatives and to address the evolving environmental issues. Major emphasis is being placed on the facilities in the Bethel and Melton valleys (X-10) site and includes the development of a Life Sciences Complex that would permit the relocation of the biology activities currently located at Y-12. Strengthening of our existing long-term facilities at Y-12 is also an important element of the plan. Major new facilities construction will occur in Bethel and Melton valleys, while utility and building restoration will occur both there and at the ORNL facilities located in Y-12. Numerous tasks associated with environmental restoration and upgrade will be accomplished. The broad facilities initiatives that will begin to implement the SDP are listed below.

Facilities Plans: 1985–1990

Multiprogram General Purpose Facilities (MGPF)

The following discussion reflects, except for the minor changes noted below in Construction Projects, the planned MGPF projects listed in the current SDP. Initiatives undertaken in the near term will focus primarily on restoration and rehabilitation of the existing utility system and the installation and upgrade of environmental monitoring systems at both the Bethel Valley site and the ORNL facilities at Y-12. Particular attention has been paid to upgrading deteriorated or potentially unreliable systems. A series of general-purpose office buildings to relieve the severe overcrowding of the main research complex (4500 area) and to replace obsolete temporary structures is projected to begin in FY 1986. A multiprogram and general-purpose office and light laboratory building is proposed in FY 1987 to assist in bringing the Laboratory's nonprogrammatic life sciences activity into a planned Life Sciences Complex. In the latter part of the planning period, a series of projects to restore or replace multiprogram laboratory and office space and to upgrade general support buildings has been projected.

Programmatic Facilities

The following programmatic projects reflect the ongoing or expanded need to support specific research in the life and basic physical sciences at ORNL.

The High Temperature Materials Laboratory (HTML) (FY 1983) will be the first major new laboratory-office building built at ORNL since 1976 and only the second built since the 1960s. It will provide important new capabilities in this area of research.

Replacement of the obsolete, inadequate, and oversized facilities housing the Biology Division is projected to begin with the Toxic Substances Laboratory and Animal Facility. Several additional major projects now being identified will be required to provide adequate housing for the remainder of the division. Because of the length of time required to replace the division's current housing, a few relatively small restoration projects will be necessary for the existing Biology Division facilities in order to maintain their usefulness in the interim.

Another projected facility is the Health and Safety Research Laboratory, which will provide space for the safe handling of carcinogenic chemicals and radionuclides. This work is currently hampered by inadequate, overcrowded, and inappropriately located facilities in the main research complex.

The Analytical Mass Spectrometry Laboratory (AMSL) is currently isolated from its primary users by its security-constrained location at Y-12. A proposed project would provide housing for the AMSL adjacent to its primary users at the Bethel Valley site. The relocation would permit this world class facility to be more effectively shared with industry and the academic community in an open environment.

A Solid State Sciences Research Facility (referred to as Surface Sciences Research Facility in the SDP) is needed to consolidate and provide appropriate housing for currently dispersed research activities in such areas as ion-surface studies, laser analysis, and development of semiconductors.

A new major research facility, HFIR-II (High Flux Isotope Reactor–II), has been proposed as a Laboratory-wide New Initiative. This facility, to be located in Melton Valley, is undergoing a series of reviews. A number of facilities options will be investigated as the project develops.

Environmental Concerns

The emphasis of ORNL's Environmental Management Program is to ensure that the ORNL facilities comply with all federal and state laws and regulations and Department of Energy (DOE) Orders regarding the discharge of both radioactive and nonradioactive hazardous materials into the environment and to protect the environment from negative impacts of ORNL operation. During the past 40 years, governmental regulations regarding discharges have changed continually. As a result, disposal technology considered adequate in the past is no longer acceptable under today's more stringent conditions. Currently, regulations set forth by the State of Tennessee and the federal government require ORNL's environmental program to undertake two types of responsibilities: (1) controlling releases from present operations and (2) engineering remedies for problems resulting from 40 years of past operations.

On August 23, 1983, a compliance evaluation inspection of ORNL was conducted by the State Department of Health and Environment and the Environmental Protection Agency (EPA). This inspection reviewed ORNL's National Pollution Discharge Elimination System (NPDES) permit and compliance with the Tennessee Water Quality Act. Following the inspection and subsequent review of ORNL environmental reports and documents relating to discharges of chemicals and radionuclides, the state inspection team concluded that ORNL had a variety of serious environmental problems that violated the Tennessee Water Quality Control Act.

The Environmental Management, Waste Management Operations, and Engineering staffs at the Laboratory have developed a five-year plan directed toward engineered abatement solutions for a variety of these problems. ORNL is working toward compliance with state and EPA environmental discharge criteria and will continue to do so according to our five-year environmental plan. These projects are proposed for funding through FY 1989 as shown in Table 26. The environmental management capital projects are not included in ORNL's current MGPF (beyond FY 1987) or GPP (beyond FY 1986) lists because of the magnitude of required funding.

Table 26. Proposed funding for Environmental Concerns Project[a]

($ in millions)

	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	TEC
Environmental Concerns Project	19.7	40.9	99.0	153.9	93.5	407.0

[a]Includes the Environmental Monitoring Systems Upgrade, Phases I and II.

General Plant Projects (GPP)

Initially, a major portion of the GPP budget will be used to accomplish a variety of environmental restoration and upgrade tasks. However, because GPP is also a primary source of both the smaller facilities' restorations as well as programmatic support activities, it is imperative that alternative funding sources (the proposed ORNL Environmental Restoration and Upgrade Project) for the environmental projects be obtained. Our specific requirements are discussed below in General Plant Projects and General Purpose Equipment.

Construction Projects

A summary of funded, budgeted, and proposed construction is presented in Table 27.

Table 27. Major construction projects by fiscal year

($ in millions)

Title	1983 and before	1984	1985	1986	1987	1988	1989	1990	TEC
Funded construction									
Program-related projects									
AIM,[a] Calutron		0.3							0.3
AIM, En Tandem		0.3							0.3
Radioactive Waste Facilities Improvements	21.3	1.0							22.3
HTML[b]	1.0	9.0	6.6	2.7					19.3
MGPF[c] projects									
Laboratory Emergency Response Center	2.0	2.2							4.2
Rehabilitation of Electrical Service for Research Facilities (Y-12)	1.0	3.0	1.0						5.0
Cooling-Water Facilities Restoration		0.6	2.0	1.4					4.0
Improvements to Existing Sewage Treatment system		1.5							1.5
Total	25.3	17.9	9.6	4.1					
Budgeted construction									
Program-related projects									
ARIM,[d] HFIR[e] heat exchanger			0.3						0.3
AIP,[f] bulkshielding reactor			0.2						0.2
MGPF projects									
Environmental Monitoring Systems Upgrade, Phase I			1.0	2.5					3.5
Primary Electrical Distribution System Restoration			0.5	1.7					2.2
Central Chilled-Water System Restoration			1.1	3.6					4.7
Total			3.1	7.8					
Total Funded and Budgeted	25.3	17.9	21.0	11.9					
Proposed projects									
Program-related projects									
AIM, 25 MV Tandem Extended Tube Upgrade				0.5					0.5
AMSL[g]					3.4				3.4
AIM, HFIR Critical Facility				0.3					0.3
AIM, HFIR Remote Sampling Facility				0.3					0.3
AIM Beam Lines				0.3					0.3
Solid State Sciences Research Facility[h]						4.0	5.0		9.0

Table 27. (continued)

($ in millions)

Title	1983 and before	1984	1985	1986	1987	1988	1989	1990	TEC
HFIR-II				6.2	14.6	11.6	50.0	90.0	*i*
Central Waste Disposal Facility				1.0	6.5				7.5
Health and Safety Research Laboratory					3.0				3.0
Toxic Substances Laboratory and Animal Facility[j]					7.2	29.6	1.7		38.5
Upgrade Air Supply, Part I					3.2				3.2
Upgrade Air Supply, Part II						3.0			3.0
AIM, ORELA[k]					0.6				0.6
AIM, 25 MV Tandem Upgrade					0.6				0.6
Environmental projects									
ORNL Environmental Restoration and Upgrade[l]			16.2	35.9	99.0	153.9	93.5		398.5
MGPF projects									
Environmental Monitoring Systems Upgrade, Phase II				1.0	4.0				5.0
Upgrade Steam Distribution System[m]				1.5	5.0				6.5
Upgrade Fire Protection, ORNL at Y-12				1.8					1.8
Central Administrative and Support Building					1.2	4.1			5.2
Utilities Restoration, Piping Systems (ORNL at Y-12)[n]					0.6	3.4			4.0
Electrical Systems Upgrade[o]					3.0				3.0
West Core Facilities[p]						10.0			10.0
Potable Water System Upgrade						4.5			4.5
Utilities Restoration, Electrical Systems (ORNL at Y-12)						4.0			4.0
Support Facilities Upgrade, Phase I[q]						5.0			5.0
Technical Support Facility[r]							10.0		10.0
Upgrade Steam Distribution System, West End[s]							5.0		5.0
Existing Light Laboratory/Office Upgrade, Phase I[q]							5.0		5.0
Street System Rehabilitation and Additions							5.0		5.0
Existing Laboratory Upgrade							10.0		10.0
Support Facilities Upgrade, Phase II								5.0	5.0
Existing Light Laboratory/Office Upgrade, Phase II								10.0	10.0

[a]AIM = Accelerator Improvement and Modification.
[b]HTML = High Temperature Materials Laboratory.
[c]MGPF = Multiprogram General Purpose Facilities.
[d]ARIM = Accelerator and Reactor Improvement and Modification.
[e]HFIR = High Flux Isotope Reactor.
[f]AIP = Accelerator Improvement Project.
[g]AMSL = Analytical Mass Spectrometry Laboratory.
[h]Formerly called Surface Sciences Research Facility.
[i]Not yet determined.
[j]Change in total estimated cost (TEC) reflects the costs of the facility sited in Bethel Valley at the X-10 site in lieu of at Y-12.
[k]ORELA = Oak Ridge Electron Linear Accelerator.
[l]ORNL = Oak Ridge National Laboratory.
[m]Replaces the previous Laboratory Hot-Water District Heating System project.
[n]Formerly phase II of the same project; previous phase (phase I) will be accomplished with general purpose project (GPP) and other funds.
[o]Expanded from previous project to include lighting and alarm systems, which required restoration.
[p]Replaces the previous Bioscience and Technology Facility and houses only multiprogram life science functions.
[q]This project was split into phases from previous listings to accelerate the addressing of more urgent needs.
[r]Costs and scope of this project have been reduced as a result of the proposed relocation of some potential occupants to the Energy Systems Corporate Office Complex.
[s]This project may also be submitted as an in-house energy management project.

Environmental Concerns Project

ORNL Environmental Restoration and Upgrade ($398.5 Million)

The Environmental Restoration and Upgrade Project will accomplish the capital tasks as defined in ORNL/TM-9200, *Environmental Management at ORNL, Five-Year Project Plan (FY 1985–1989).* Based on current regulatory requirements and ORNL operations, the capital tasks listed will reduce pollutant discharges at ORNL to acceptable levels. Subsequent changes in regulatory requirements, affecting the scope of ORNL environmental needs, will be addressed independently of this project. Sources of environmental pollutants at ORNL that are the results of past practices will be dealt with to render them harmless to the environment. The three areas of project scope are as follows:

1. **Nonradioactive Waste Management.** Improvements and additions to existing facilities will be provided to collect, transfer, treat, and store hazardous nonradioactive wastes. The modified facilities will eliminate or control hazardous pollutant discharges to surface water, groundwater, air, and the ground. Treatment facilities will include collection tanks, carbon absorption, reverse osmosis, ozonation, ion exchage columns, and evaporation systems for the various waste streams at ORNL. Additional facilities to store and/or recycle other hazardous wastes before their transport off-site will also be provided.
2. **Radioactive Waste Management.** Improvements and additions will be made to existing facilities used to collect, transfer, treat, and store radioactive wastes at ORNL. These facilities include collection tanks, transfer lines, ion exchange columns, evaporators, active and inactive shallow land burial sites, inactive percolation pits and trenches, and liquid holding ponds. Additional facilities will also be provided to monitor, collect, or divert groundwater and surface water flowing through low-level contaminated soils adjacent to buildings where radioactive materials were or are being used.
3. **Environmental Monitoring.** Environmental monitoring systems that are outdated, lack adequate sensitivity, and are unreliable will be replaced. Isotopic and quantitative monitoring systems will be added to selected areas where coverage of the existing system is inadequate or nonexistent. Improved data acquisition, handling, and collection systems will be provided. To enhance data analysis, the new monitoring systems will provide digitized output.

Funds for the cleanup of contaminated ponds and White Oak Lake, asbestos removal, engineering project support and management, site characterization, and other expense projects are included in the scope of this project.

Multiprogram General Purpose Facilities (MGPF) Program

The objectives of MGPF site-development activities at ORNL during the next five years are to

1. provide for the efficient and reliable functioning of existing facilities,
2. renew or replace age-deteriorated and obsolete facilities,
3. improve use and eliminate overcrowding of existing facilities, and
4. eliminate redundant and temporary facilities.

These four objectives provide the basic framework and direction for ORNL's MGPF facilities projects during the period. The long-term task of implementation will require ten years or more to

complete fully. It will require the judicious use of both MGPF and Laboratory GPP funds. Laboratory maintenance and operating funds will also be required to restore and modify facilities, relocate personnel, and eliminate temporary facilities.

The MGPF projects that will help fulfill these objectives are described in the following sections.

FY 1985 Projects

Environmental Monitoring Systems Upgrade, Phase I
(TEC $3.5 Million)

This project will result in the upgrading or addition of selected air- and water-monitoring stations where existing stations do not provide adequate coverage or where new requirements demand new or improved stations; the installation of new monitoring instrumentation that will monitor ORNL's discharge from five stacks with appropriate sensitivity and quality; and the improvement of central data collection, analysis, and storage. The air- and water-monitoring stations to be replaced are outdated and unreliable. The new isotopic and quantitative systems will provide adequate coverage in areas where current coverage is inadequate or nonexistent. The output will be digitized, resulting in an improvement of data acquisition, handling, and collection. This project is needed to help bring ORNL into compliance with EPA, DOE, and other directives and to upgrade ORNL's monitoring systems to meet Nuclear Regulatory Commission (NRC) and other acceptable nuclear standards.

Primary Electrical Distribution System Restoration
(TEC $2.2 Million)

Restoration of components of the electrical distribution system is needed to provide reliable support to ORNL. This effort will involve the replacement of aged, obsolete, and unreliable components in the ORNL 13.8- and 2.4-kV electrical distribution systems. Among the specific tasks will be the replacement of deteriorated cable, transformers containing deteriorated insulation, and fused disconnect switches; rebuilding of distribution lines; and improved protection from lightning. This project will correct deficiencies such as the use of high-voltage cable and switchgear in violation of national electric codes, unreliable switchgear, deteriorated equipment, and inadequate protection from lightning and will circumvent possible environmental hazards associated with polychlorinated-biphenyl-filled transformers.

Central Chilled-Water System Restoration
(TEC $4.7 Million)

Consolidating and upgrading the chilled-water equipment serving the central research and administration complex will involve replacing aged and obsolete equipment in the ORNL central chilled-water system, consolidating air-conditioning equipment in a central compressor facility, and converting cooling-water lines between Buildings 4509 and 4500N to chilled-water use. This project is necessary for several reasons: the system is deficient, the tower capacity is inadequate for present peak demands, and the equipment is more than 35 years old. The current system requires annual overhaul to maintain marginal performance. Replacement parts are no longer available and must be custom fabricated. A compressor failure would take 12 to 15 months to remedy and would

adversely affect $150 million per year in research programs, the $21 million computer center, and 32% of ORNL's population.

FY 1986 Projects

Environmental Monitoring Systems Upgrade, Phase II
(TEC $5 Million)

Phase II of the Environmental Monitoring Systems Upgrade project continues the modernization of existing liquid and gaseous environmental monitoring stations at ORNL begun in Phase I and adds stations to provide more detailed coverage of the surrounding area. The monitoring information will be transmitted to a central location for processing and analysis. As currently envisioned, the work will include the fabrication and installation of NPDES radiological water monitoring stations, stack monitoring stations, and local and remote air monitors.

Upgrade Steam Distribution System
(TEC $6 Million)

This project will replace the existing severely deteriorated underground steam lines with new underground lines. A feature of the new lines will be a leak-detection system to permit the location of any future jacketing failures before they degrade the insulation. Condensate return lines are to be added from major steam users to the extent that they can be economically justified. Additional pipe segments to provide looping will be installed in high-usage vital areas. Some isolation valves will be added to increase system flexibility. The project will save a significant amount of energy currently lost by the existing system.

Upgrade Fire Protection, ORNL Facilities at Y-12
(TEC $1.8 Million)

The correction of deficiencies identified in fire protection audits of the Y-12 Plant by the operating contractor and DOE audits will help bring ORNL facilities at Y-12 into compliance with DOE Order 5840.1. This, in turn, will aid ORNL in maintaining the "improved risk" concept of fire protection, which includes life, safety, and property conservation. The upgrading will reduce or eliminate recurring financial and operational losses; provide sprinkler protection for several office areas, laboratories, and workshops; and allow higher water pressure on the upper floors of the building that houses many of the animal research facilities.

FY 1987 Projects

Central Administrative and Support Building
(TEC $5.2 Million)

The proposed multistory, 4600-m^2 (50,000-ft^2) building will provide needed adequate and efficient offices for approximately 225 administrative and support personnel at ORNL. Currently, ORNL has more than 1400 multiperson offices and an additional 950 that according to DOE criteria are too small. In the main research complex (4500 area), there are 360 deficient offices.

No administrative and support divisions are currently housed in a single location. The proposed facility would bring together Employee Relations, Finance, Law, Central Management, Technology Transfer, and Computing and Telecommunications administration to a central location, which would eliminate fragmentation and would improve operational efficiency. In addition, the removal of these personnel from the 4500 complex would permit this facility, which currently houses seven research divisions, to provide space for consolidating additional fragmented and isolated research organizations whose principal need is office space. These relocations and consolidations would permit the removal of approximately 1800 m^2 (20,000 ft^2) of obsolete temporary space.

The proposed location of the facilities north of Building 4500N and west of Building 5000 conforms with the idea of having a central circulation spine for the Laboratory and provides a central administrative facility easily accessible to both the Laboratory and the public.

Utilities Restoration—Piping Systems, ORNL at Y-12
(TEC $4 Million)

The first part of a program to upgrade or replace inadequate utility systems serving ORNL facilities at the Y-12 Plant provides for restoring the most critical parts of the outdated and unreliable instrument air and demineralized water distribution systems. The work will correct deficiencies and restore acceptable reliability and capacity to these systems. Because the systems support multiple programs of national importance, these improvements will reduce or eliminate untimely interruptions and ensuing negative impacts on program schedules.

Electrical Systems Upgrade
(TEC $3 Million)

The electrical systems upgrade project is planned to complete the system improvements that were begun with the FY 1985 Primary Electrical Distribution System Restoration Project. The remainder of the electrical distribution system upgrade, the restoration of several street lighting circuits, the undergrounding (to existing ducts) of the main alarm trunk lines to the Laboratory Protection Headquarters, and similar small tasks will be pursued with this project.

FY 1988 and Beyond Projects

West Core Facilities
(TEC $10 Million)

This project will consist of two distinct parts. The first will install some of the basic, general site-support systems at the west end of the Bethel Valley site. The second will construct a new multistory office, light laboratory, support building to house the multiprogram biotechnology activities, the Laboratory's support activities in the life sciences, and various general-purpose facilities in support of all the life science activities.

The general site support systems to be installed include extension to the electric distribution, communication, site drainage, water, sewer, compressed air, natural gas, and central heating system into this newly developing portion of the site. In addition, the existing roads will be upgraded and extended to connect with Bethel Valley Road. Additional employee parking areas will be provided to serve the increased population of the area.

The building will contain approximately 5100 m^2 (55,000 ft^2) of gross floor area. This space will be divided into offices for approximately 120 personnel, general-purpose light laboratories, a major branch library including a repository for archiving experimental data, a small computational facility, and a food service facility serving the western portion of the site.

The justification for such a complex includes both a significant enhancement of efficiency and effectiveness for research and support activities resulting from greatly improved personnel interaction, and the synergistic benefits of having related activities adjacently located. In addition, important cost savings resulting from improved facility utilization and shared facilities are projected. For example, the multidivisional biotechnology program requires fermentation capabilities to be shared by Biology, Chemical Technology, and other divisions. Currently three overcrowded libraries serve life science activities. These would be combined into one large, more efficient operation, which would reduce the overall personnel and space requirements.

Potable Water System Upgrade
(TEC $4.5 Million)

A recently completed evaluation of the potable water system identified a variety of deficiencies in our existing system. This project would correct the major deficiencies. Primary among these deficiencies is the lack of a backup supply line from the Water Treatment Plant near Y-12. Breaks have occurred and could occur again in locations that are so time-consuming to repair that the storage capacity at ORNL is exhausted before repairs are complete. In addition, the 7600 area has neither storage nor redundancy, which makes it particularly vulnerable to fire if a break in its feed were to occur. The proposed project would install a second line from Y-12 that would give both the Laboratory and the 7600 area the needed redundancy. Other more minor improvements include loops for improved fire protection and replacement of deteriorated lines in the 7000 area.

Utilities Restoration Electrical Systems, ORNL at Y-12
(TEC $4 Million)

The electrical systems project addresses a number of significant deficiencies in the basic utilities systems supporting ORNL activities at Y-12. These systems were installed in the early 1940s and have deteriorated or become obsolete to the point that their long-term ability to service ORNL activities reliably and effectively is in question.

Although all facilities have major utilities deficiencies, only those expected to experience long-term use by the Laboratory (Fusion and Engineering Technology) will be fully upgraded. Other facilities will be upgraded only as required to maintain operation until relocation can be accomplished.

The exact dimensions of these items are not known at this time. The rate of future deterioration, the availability of GPP funds to accomplish some items, and the schedule of relocation of activities to other sites will affect the overall size and specifics of this task.

Support Facilities Upgrade, Phases I and II
(TEC $10 Million)

The main support facilities at the Laboratory, including the Materials Department and Plant and Equipment Division maintenance and support shop activities, are on the average 30 years old. In addition, some of these activities were placed in facilities no longer required by the programs and not in facilities designed and located to enhance the effectiveness and efficiency of their operation.

This situation has resulted in some facilities containing building support systems that are worn out or inadequate for current use. A number of facilities contain obsolete equipment and are configured such that efficient response to current needs is hampered. The retrofitted, formerly programmatic space has deficiencies similar to those listed above and, in addition, has led to the unnecessary fragmentation of support activities. This project will address those deficiencies that are beyond the scope of maintenance and GPP in such facilities as Buildings 7001, 7002, 7012, 7007, 7009, 3044, and 3074.

Technical Support Facility
(TEC $10 Million)

This new, approximately 6000-m^2 (65,000-ft^2) facility will house the Engineering Division, Quality Assurance and Inspection, and other associated support groups. The building will be predominantly an office facility but will include laboratory and shop space in support of quality assurance work. The building will permit the demolition of several obsolete, substandard structures while bringing currently separated, important support functions together and placing them in the mainstream of Laboratory activities.

Upgrade Steam Distribution System, West End
(TEC $5 Million)

The west end project is a companion to the Upgrade Steam Distribution System (FY 1986) and completes the upgrade and restoration of those portions of the system not addressed in the initial project. The upgrade project includes replacement of the remaining deteriorated bellows expansion joints, replacement of several deteriorated underground lines serving the western portion of the site, installation of condensate return lines, and the installation of several additional segments to provide looping between existing branches.

Existing Light Laboratory/Office Upgrade, Phases I and II
(TEC $15 Million)

Throughout the past 20 years, the multiprogram light laboratory/office facilities have seen numerous physical changes in response to shifting program requirements. To meet these requirements laboratories have been converted to office space and vice versa. Each change, which has brought greater deviation from the original design, has tended to reduce the the effectiveness of the building function. In addition, many of these facilities contain some worn-out or obsolete building support systems. This upgrade project will restore these building support systems and will modify the facilities to their highest and best use consistent with current and projected needs. Obsolete temporary structures will be replaced and additional space added where required. Included will be Buildings 3500, 3523, 3550, 3587, 3047, 4500N, 4500S, 4508, 9201-3, and 9204-1.

Street System Rehabilitation and Addition
(TEC $5 Million)

This project will consist of two parts: (1) the reconstruction and rehabilitation of various deficient portions of the existing street system and (2) the extension of streets into newly developing portions of the site.

Major portions of the street system serving Melton Valley were developed over the years as temporary or light-duty roads. They were originally installed to construct the experimental facilities

located in the valley and were paved over. This process has left portions of the primary access that (1) are poorly aligned (both horizontally and vertically), (2) have inadequate pavement and shoulder widths, and (3) have sub-bases that are subject to failure. The first part of this project will correct these deficiencies.

The areas south and east of the Building 6000 area are projected to be the sites of several new facilities. Individual facilities projects would then be able to extend driveways and parking areas from this street system.

Existing Laboratories Upgrade
(TEC $10 Million)

Most of the multiprogram laboratory space at ORNL was constructed in the 1950s and 1960s, which means these laboratories are 25 to 35 years old—near the end of their original functional life. This fact is confirmed in several recent evaluations of their adequacy, including the MGPF Inventory (1981) and the Real Property Inventory System (1984). Deficiencies range from building support systems and utilities that are worn-out or inadequate for current use to operations that are overcrowded, use obsolete equipment, or have a layout that is inefficient for current use. This project will focus on renewing these multiprogram research laboratories by addressing deficiencies that are beyond the scope of maintenance and GPP in such facilities as Buildings 3508, 4501, 4505, 3019, 3026C, 3026D, 5500, and 5505.

General Plant Projects (GPP) and General Purpose Equipment (GPE)

General Plant Projects

The continued lack of adequate GPP funding, coupled with a lack of major line-item funding for restoration and new facilities, has resulted in a significant backlog of ongoing facilities deficiencies. Numerous studies including the MGPF inventory of deficiencies and our Facilities Evaluation Studies indicate that the Laboratory faces a backlog of deficiencies in the range of $200 million. Not all of these deficiencies, however, are most logically corrected with GPP funds. An estimated minimum of $150 million should receive line-item support, which means that the GPP backlog of general-purpose facilities deficiencies is about $50 million.

The $7.4 million for FY 1985 indicated in Table 28 is largely consumed by pressing environmental concerns. The FY 1987 and beyond funding needs have been substantiated by DOE Headquarters. The analysis showed that a constant funding level in excess of $14 million is required to maintain the ongoing operation of our installation. The $14 million shown in FY 1987 starts the ramp upward toward a peak of $21 million in FY 1988. Based on the programmatic projections of each yearly total during the planning period, about $6 million should be used to support program requirements. The remaining $8 million to $15 million would address the deficiencies identified in our evaluations. Likewise, the $2.4 million from Program AR in FY 1985 will provide funds for much-needed improvements or additions to waste management facilities. These will correct prob-

lems that have contributed to environmental concerns. This portion of the budget is also expected to increase.

Table 28. General Plant Project (GPP) funding needs through FY 1990

($ in millions—BA)

	Fiscal year								
	1982	1983	1984	1985	1986	1987	1988	1989	1990
General Laboratory GPP (AT Program)	4.3	3.5	4.2	7.4	8.0[a]	14.0	21.0	21.0	19.0
Waste Management (AR Program)	0.8	2.0	1.9	2.4	3.5	3.2	3.2	3.2	3.2
Energy Conservation (WB Program)	0.7	1.5	2.0	0.0	1.0	1.5	1.5	1.0	1.0
Total GPP funding	5.8	7.0	8.1	9.8	12.5	18.7	25.7	25.2	23.2

[a]A supplemental request for an additional $5 million has been made to address critical environmental issues.

General Purpose Equipment

Because of the continued lack of adequate GPE funding, the Laboratory is being forced to expend large amounts of funds for maintenance of equipment to extend its useful life well beyond the normal life expectancy. This expenditure of funds causes the Laboratory to "mark-time" with existing equipment and lose many advantages offered by current state-of-the-art improvements.

A conservative estimate of approximately $45 million will be required over the next six years (FY 1985–FY 1990) to meet needs in numerous areas to maximize accuracy, productivity, efficiency, and safety. The installation of environmental monitoring equipment and upgrade of various stack monitoring alone will account for over $10 million during this period. Several other areas that will continue to require significant amounts of GPE funding are (1) shop equipment for precision measurements and increased productivity, (2) smaller, more fuel-efficient vehicles that upgrade the vehicle fleet, (3) security and safeguard equipment, and (4) small computers.

The FY 1984 GPE Financial Plan of $4 million emphasizes the acute GPE funding shortage at ORNL. Major items of equipment (equipment items with TEC greater than $1 million and ADP greater than $400 thousand) constitute $2.3 million of the above figure, namely $1.5 million for computer upgrade and $800 thousand for the CAD/CAM (computer-aided design/computer-aided manufacturing) system. This leaves only $1.7 million to be allocated on a quarterly basis for all other equipment items, and as a result, only two of the four quarterly GPE calls for proposed acquisitions could be made this fiscal year. This unfavorable situation adds greatly to the existing large backlog of equipment items that were requested but not funded because of a lack of sufficient funds (Table 29).

Table 29. General Purpose Equipment

($ in millions)

FY 1983	FY 1984	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990
4.0	4.0	6.4	7.2[a]	8.0[b]	8.0	8.0	8.0

[a]A supplemental request for an additional $1 million has been made to address critical environmental concerns.

[b]This figure has been substantiated by DOE Headquarters.

Automated Data Processing Equipment (ADPE) Requirements

In recent years the computational resources available to researchers at ORNL have lagged behind their needs both in capacity and in capability. The reasons for this lag are complex and varied, but senior management within ORNL and within Martin Marietta Energy Systems, Inc., is determined to work with DOE to remedy the situation as soon as possible. One important step will be the production of a strategic plan for computing at ORNL. This plan will be part of a larger strategic plan for computing for all of Martin Marietta Energy Systems, Inc.

ORNL obtains most of its centralized computing capacity from the Computing and Telecommunications Division (CTD) of Martin Marietta Energy Systems, Inc.* CTD manages central computing systems at ORNL, at the Oak Ridge Gaseous Diffusion Plant (ORGDP), and at the Y-12 Plant. Organizationally, CTD reports to a Vice President of Martin Marietta Energy Systems, Inc. CTD is responsible for long-range planning of acquisitions of computers for general-purpose use and is directly involved in the approval chain for all types of ORNL computing facilities.

Presently ORNL provides input to the ADPE planning process through a computing steering committee that reports to the Laboratory's Executive Director. The Executive Director represents ORNL in a liaison or coordinating role with CTD management. Beginning in FY 1985, ORNL will appoint a Manager of Computer Planning who will work with ORNL computer users, ORNL and Energy Systems management, CTD, and DOE to prepare a long-term strategic plan for computing for ORNL. This plan will be integrated with a larger plan covering all of Martin Marietta Energy Systems, Inc., and will be updated yearly. The present ORNL computing steering committee will have oversight responsibility for this planning process.

Automated data processing (ADP) planning at a multiprogram laboratory such as ORNL is necessarily complicated. At ORNL over 2400 staff members use central computing facilities in a manner that substantially impacts their R&D projects. These projects are funded by hundreds of separate programs, each of which has its own goals and ADP needs.

A long-range strategic plan must address the steps needed to answer several important questions. What is the proper mix of centralized versus "dispersed" computing? How should the dispersed computing be organized, for example, as minicomputers serving groups or as personal computers serving individuals? Can and should the dispersed equipment be connected via a

*The Fusion Energy network also supplies a significant capability to the ORNL Fusion Energy Program.

high-speed data network? How can funds from diverse programs be combined to purchase centralized computing equipment? How should computing resources be allocated? How can one determine whether or not computational resources are being used in a cost-effective manner?

Unfortunately, several problems having to do with computing at ORNL are so critical that they cannot wait until a comprehensive plan can be devised, approved, and implemented. Among these problems are a shortage of interactive computing capacity and inadequate access to high-capability computers.

Interactive Computing

Highest priority must be assigned to providing greater capacity for interactive computing. Long response times and log-in queues for the primary Laboratory interactive system (the five-processor PDP-10 system) are a serious detriment to the productivity of many employees. The long-term solution to this problem requires careful consideration. It may involve a combination of augmenting the central interactive system, acquiring minicomputers for special-purpose applications, and using personal microcomputers for the jobs that they can handle more efficiently. Careful planning will be needed to ensure that dispersed minicomputers and microcomputers can communicate effectively. The possibility of a distributed processing computer network will also be considered. Interim plans are in progress to acquire a PDP-10 for the Finance and Materials Division and a multiprocessor supermini distributed system. They should provide at least temporary relief.

High-Capability Computers

A second problem that ORNL must work with CTD and DOE to solve is how to provide greater computing capability for its research staff. One important aspect of a computer's capability is the speed of its central processor. For computers used in scientific and engineering tasks, processor speed is usually measured in megaflops. A one-megaflop computer can perform a million floating point operations each second. Table 30, which lists the major CTD operated computer systems serving ORNL, shows that, in terms of processor speed, the capability of the computers serving ORNL has not increased significantly during the past 12 years.

During that CY 1972–CY 1982 period, the state-of-the-art in computing advanced significantly. High-capability computers coming on the market in 1984 can perform in excess of 500 million floating point operations per second.* These new supercomputers are having a big impact in many areas of physical science and engineering. Scientific hypotheses can be tested, and computer modeling can reduce or eliminate the need for expensive or even impossible experiments.

Lack of access to high-capability computers threatens to artificially constrain the areas of research in which the ORNL research staff can effectively participate. ORNL management views this trend as highly undesirable and recognizes that it must plan to provide researchers with the computing resources they need to accomplish their missions. Again, careful planning is necessary to ensure that expensive and valuable resources are used productively and are acquired in a cost-effective manner.

*These speeds are achieved largely by performing many operations in parallel. Programs that are not well adapted for vector or parallel processing will run more slowly.

Table 30. Major computer systems serving Oak Ridge National Laboratory

System description	Installation date of basic computer system	Approximate processor speed (megaflops)
Oak Ridge National Laboratory		
IBM 3033, with 16-MB memory and 6 channels	October 1979	2.5
IBM 3033, with 16-MB memory and 6 channels[a]	November 1979	2.5
DEC KL10, with 2048-K-word memory, 5 processors, 10 channels, 24 disk drives, and 3 magnetic tape drives	January 1977	0.25
DEC KA10 plus SEL and PDP minicomputers to collect and analyze data at the Oak Ridge Electron Linear Accelerator	April 1977	<0.25[b]
DEC KL10 with 1024-K-word memory, dual processor, 5 channels, 8 disk drives, and 2 magnetic tape drives to collect and analyze data for the Fusion Energy Division	July 1976	0.25[b]
Oak Ridge Gaseous Diffusion Plant		
IBM 360/195, with 4-MB memory, 9 channels, 40 disks, 3 drums 17 magnetic tape drives, and 1 mass-storage device	November 1972	2.4
IBM 4341 with 16-MB memory, six channels, sixteen 200-MB and five 400-MB disk drives, and fourteen magnetic tape drives	January 1981	0.6

[a]Combined equipment of these systems: 107 disks, 1 mass-storage device, and 14 magnetic tape drives.

[b]Per processor in a multiprocessor system.

The ORNL computing steering committee has identified numerous researchers who need the capability of a Class VI* computer to perform their work effectively. The committee has estab-

*A Class VI machine should have a nominal megaflop rating of at least 100.

lished an immediate load of 3000 to 3500 h/year, and it expects this load to grow rapidly, especially if the interactive systems are improved sufficiently to allow program development during regular working hours.

Two important developments expected during FY 1985 will significantly impact planning for high-capability computers to serve researchers at ORNL. First, the uranium enrichment programs are expected to acquire a Class VI computer to be located at the K-25 site in Oak Ridge. Second, the DOE Office of Energy Research (OER) plans to establish a supercomputer network to serve its programs.

The Class VI computer to be located at K-25 will be used primarily to support the gas centrifuge and laser isotope separation processes, but possibly some time will be available for other users. ORNL will explore the possibility of acquiring useful and effective access to this computer for its researchers, while recognizing the security requirements and the serious time constraints of the uranium enrichment programs.

ORNL will work closely with OER and will attempt to acquire time on and access to the interim Class VI machine that is scheduled for installation at Lawrence Livermore National Laboratory in FY 1985. Unfortunately many researchers at ORNL, especially those not working on OER programs, will not be allowed time on the OER network.

At present a major computer acquisition to be located at ORNL is included in the FY 1986 ADP Long-Range Site Plan. From present trends, the capacity of a Class VI machine will be needed at ORNL by September 1986, the planned date for installation of this acquisition. The ORNL computing steering committee has determined, moreover, that many important problems exist at Oak Ridge that require the power of a Class VII computer. The need for Class VI and Class VII computing will be carefully evaluated as part of the long-range strategic plan. A serious attempt will be made to predict the impact of the OER and uranium enrichment Class VI acquisitions on the needs of a Class VI computer at ORNL. The question of whether or not special-purpose devices such as attached processors or parallel processors can effectively substitute for a Class VI computer will also be carefully studied.

Research in Parallel Computing

The much-heralded recent advances in computing technology have concentrated not so much on making computers intrinsically faster as on making them smaller and cheaper. Advances in speed have largely resulted from more operations being performed in parallel.

During the next five years, new types of computers with radically different architectures emphasizing many processors working in parallel will come on the market. Much work needs to be done to reprogram algorithms to take advantage of these new parallel processing architectures. Initial studies in this area are under way in FY 1984, with support provided by ORNL discretionary funds. This program will be continued in FY 1985 and will be aided by the purchase of an experimental parallel processing device.

Computer Networks

ORNL has cooperated with CTD in establishing interconnections among many computing systems. These interconnections mostly consist of telephone lines. Technology now exists that is more

versatile and less expensive. The ORNL steering committee initiated a project to design and build an Oak Ridge data network based upon broad-band cable-television technology. This approach was rapidly adopted by other parts of Energy Systems, and the system began operation at the end of FY 1984. This network will provide an opportunity to set up a distributed processing network capable of serving all of Martin Marietta Energy Systems, Inc., in the Oak Ridge area.

Personal Computers

The recent advances in microcomputers provide ORNL with an important opportunity to improve the capability and productivity of its employees. ORNL recognizes that careful planning is necessary to take maximum advantage of this opportunity and to do so in a cost-effective manner.

A center for support of personal computers will be set up and given the responsibilities of encouraging software and hardware standardization, achieving economics of scale in purchasing and maintenance, and providing training and advice to users.

External Interactions

EXTERNAL INTERACTIONS

University Programs

Interactions between the Oak Ridge National Laboratory (ORNL) and the university community continue to provide a two-way flow of technical information through formal programs and informal association. Table 31 summarizes participation in energy research and development under the direction of the Laboratory's technical staff. The participation at ORNL during FY 1983 is summarized by type of program and by academic level of people temporarily assigned to programs.

The Department of Energy (DOE) University-Laboratory Cooperative Program, sponsored by the Office of Energy Research (OER), provides funding for university relations activities at both ORNL and Oak Ridge Associated Universities (ORAU). The program has been funded at a constant level for a number of years (for ORNL at $200 thousand a year). The number of participants accommodated in both the ORNL and the ORAU programs continues to decline because costs have risen steadily. However, support by the DOE University-Laboratory Cooperative Program continues to contribute significantly to the number of students and faculty assigned at ORNL from the university community, even though the majority receive financial support from the Laboratory's operating divisions and other sources (such as colleges and universities, fellowships, and grants).

A total of 957 people from the academic community participated in research programs at the Laboratory in FY 1983 (Table 31). Many of the 207 undergraduates received academic credit from their respective universities as a result of their assignment at the Laboratory, and most of the 354 graduate students were engaged in master's or doctoral research. In addition to the 351 faculty, more than 40 are Laboratory employees on a part-time, year-round basis as adjunct research participants. Of the 45 postdoctoral fellows, 6 were recipients of the Laboratory's prestigious Eugene P. Wigner Fellowship. Over 200 different universities sponsored the representatives from academia.

The ORAU Traveling Lecture Program is also funded by DOE, and in the 1983–1984 academic year, the program listed 75 staff members from ORNL. Lectures were presented at 47 universities.

For a number of years, minorities from historically black colleges and universities (HBCUs) and other educational institutions have participated in the Laboratory's university relations programs and have been employed in craft, administrative, and technical support and in professional positions. The Special Summer Program for undergraduates in science and engineering provided appointments for nine students from HBCUs in the summer of 1983.

ORNL has also participated for ten years in the Pre-co-op Scholarship Program for minority students in engineering. Employment is provided each summer for pre-co-op students who are high school graduates and who are enrolled, beginning the following fall, in one of the participating colleges and universities. After satisfactory completion of two semesters or three quarters of college, the students enter the Cooperative Education Program. Each year from three to five pre-co-ops are accepted into this program.

Table 31. Joint Oak Ridge National Laboratory (ORNL) and university programs for FY 1983

Program	Faculty	Students			Total persons	Total universities
		Undergraduate	Graduate	Postdoctoral		
Department of Energy University-Laboratory Cooperative Program						
Funded by ORNL						
Environmental sciences cooperative curriculum		1			1	1
Great Lakes Colleges Association/ Associated Colleges of the Midwest—Oak Ridge Science Semester	3	31			34	25
Southern College University Union Oak Ridge Science Semester	1	15			16	8
Special summer program[a]		9			9	8
Reactor training cooperative experiments		35			35	5
Funded by Oak Ridge Associated Universities						
Faculty research participants	20				11 9[b]	20
Student research participants		54			38 16[b]	46
Laboratory graduate participation			16		16	7
Postgraduate research training				10	10[b]	8
Nuclear science engineering and health physics fellowships			4		4	3
ORNL programs[b]						
Faculty research participants	7				7	7
Summer research interships			19		19	18
Forestry program		2			2	2
Pre-co-ops (AA)		3			3	2
Co-ops		57			57	18
Oak Ridge Graduate School of Biomedical Sciences	6		44	10	60	1
Wigner Fellows				6	6	6
ORNL guests (other sponsorship)	215		271	19	505	c
ORNL consultants	99				99	54
Total	351	207	354	45	957	239

[a]Historically black colleges and universities.
[b]ORNL operating funds.
[c]Information not available.

Opportunities to enhance ORNL's relationship with HBCUs in the Southeast continue to be explored. A program between ORNL and Atlanta University was formalized by a memorandum of understanding signed by the president of the university and the Director of ORNL on October 6, 1983. The first interaction with Atlanta University has been under way for the past year under a contractual arrangement funded by the DOE Office of Fusion Energy.

The Laboratory participates in the Cooperative Developmental Energy Program (CDEP) established at Fort Valley State College (Georgia) in April 1984, with an agreement to employ at least two CDEP students each summer in research projects appropriate to the students' major fields of study.

A collaborative arrangement between Tuskegee Institute and the ORNL Environmental Sciences Division is under way in the biomass and carbon dioxide areas. A long-term program of inter-

action with Lincoln University (Pennsylvania), Alabama A&M University, and Knoxville College is being developed by the ORNL Energy and Chemical Technology divisions in the defense waste management area. The initial focus of the program is a three-year research study of the retention characteristics of cement-based grouts. Work will continue with Lincoln University in the study of human factors that may be important in the development of radioluminescent lights for various military and civilian applications. A regional information meeting on the DOE HBCU program hosted by Oak Ridge Operations (ORO), ORNL, ORAU, The Maxima Corporation, and Knoxville College was held in July 1984.

Other work being performed on campus at HBCUs under subcontract includes projects for the Metals and Ceramics and Engineering Technology divisions by North Carolina A&T and for the Environmental Sciences Division by Virginia State University.

A request to the ORNL Biology Division from Meharry Medical College regarding a collaborative effort in the medical field is under consideration.

Technology Transfer Program

Overview of Existing Program

In 1983 ORNL proposed a new Technology Transfer Initiative designed to upgrade the program and place increased emphasis on laboratory-industry interactions while maintaining all the existing activities of the program. The following are accomplishments under the new initiative in FY 1984.

1. Increased interactions with industry by establishing working agreements that foster long-term joint research are encouraged. A unique agreement was developed with Cabot Corporation for research at ORNL in the materials sciences.

2. A joint ORNL–University of Tennessee Measurement and Controls Engineering Center was initiated to provide U.S. industry with access to a national center of excellence. A memorandum of understanding was signed between Martin Marietta Energy Systems, Inc., and the university to develop a similar Manufacturing Systems Engineering System.

3. In conjunction with DOE, a joint fund for advanced development of technologies that have significant commercial potential was established, and five initiatives were funded.

4. A blanket advanced waiver of DOE patents to Martin Marietta Energy Systems, Inc., was officially requested.

5. To increase research staff awareness, a Technology Transfer Emphasis Week was held. In addition, a National Innovation Workshop to provide instruction and guidance on successfully commercializing new technologies was conducted.

6. In conjunction with the Industrial Research Institute (IRI), the "IRI Spotlight on Oak Ridge," an industrial information meeting about materials research and technology, was conducted at ORNL, the Y-12 Plant, the Oak Ridge Gaseous Diffusion Plant (ORGDP), and The University of Tennessee.

7. A set of practices and procedures for technology assessment and development were established.

8. A consulting policy that allows ORNL staff to consult on their own time for purposes of technology transfer was established.

9. A set of practices and procedures for providing awards and incentives to employee inventors was developed.

Proposed Expansion of Technology Transfer Activities

In April 1984 the operating contractor of the DOE facilities in Oak Ridge and Paducah changed from Union Carbide Corporation to Martin Marietta Corporation. The new managing organization, Martin Marietta Energy Systems, Inc., established the Office of Research and Technology Application (ORTA), an office that will place even greater emphasis on technology transfer internally and economic development externally. Although the primary activities of this office are at ORNL, it is responsible for technology transfer activities at the other installations operated by Martin Marietta Energy Systems, Inc. As part of the new program, technology transfer activities are managed through the Martin Marietta Energy Systems, Inc.'s Vice President for Technology Applications (Fig. 6).

The purpose of the office is to institute bold initiatives with the intent of improving the process of technology transfer to industrial applications (see Table 32 for estimated staffing and funding levels). The objectives of this office are to (1) motivate the inventor, (2) have a method for quick value assessments, (3) make technology available rapidly, (4) place technology with selected clients, (5) offer protection to investing clients, (6) permit direct client assistance, (7) encourage and assist spin-off businesses, and (8) provide a modest discretionary budget to make technologies commercially attractive.

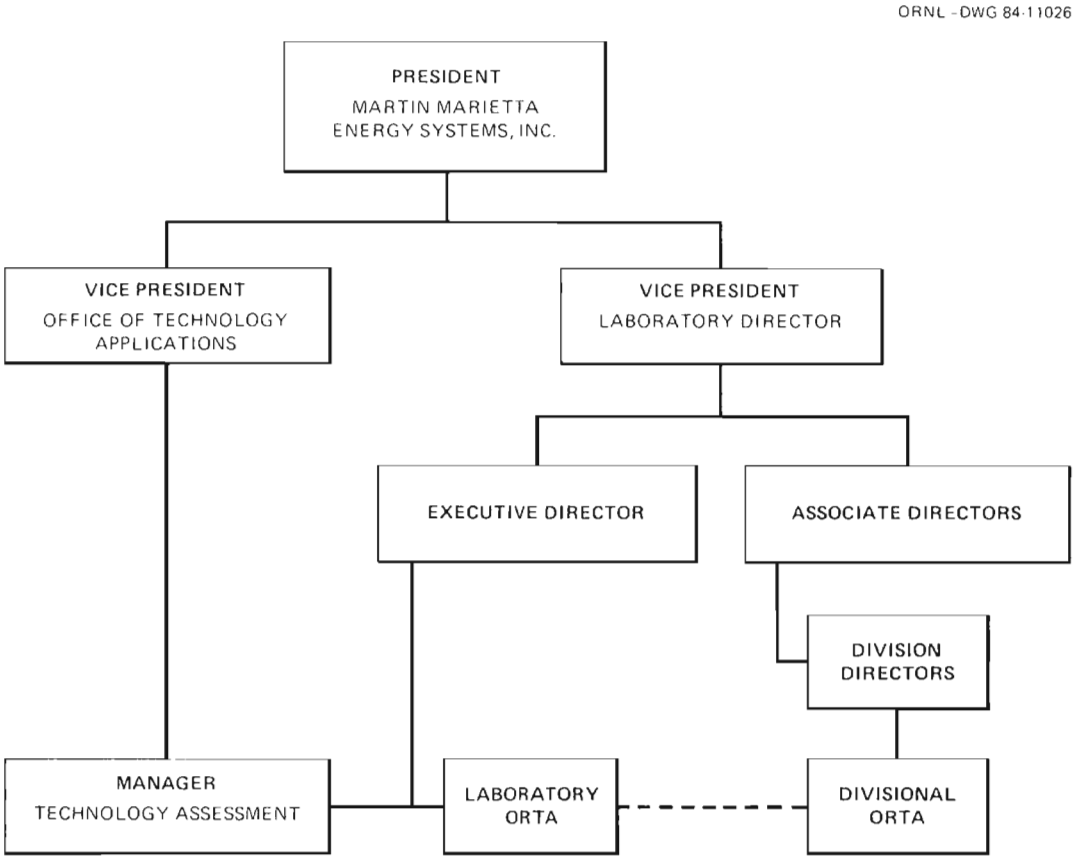


Fig. 6. Organizational and reporting level of Martin Marietta Energy Systems, Inc., Office of Research and Technology Applications (ORTA).

Table 32. Estimated staffing and expenditures[a]

	FY 1983	FY 1984	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990
				Funding, $ in thousands				
ORTA[b]	74	325	136[c]	136[c]	136[c]	136[c]	136[c]	136[c]
Other	9,700	10,500	11,400	11,400	11,400	11,400	11,400	11,400
Total	9,800	10,825	11,536	11,536	11,536	11,536	11,536	11,536
				Staffing, full-time equivalents				
Professional								
ORTA	2	2	2	2	2	2	2	2
Other[d]	60	60	60	60	60	60	60	60
Total	62	62	62	62	62	62	62	62
Support	1	1	1	1	1	1	1	1

[a]An 8.5% inflation factor has been used between FY 1984 and FY 1985 and between FY 1985 and FY 1986. For FY 1987–FY 1990, amounts are in constant FY 1986 dollars.

[b]Office of Research and Technology Analysis.

[c]These funds are for the Oak Ridge National Laboratory office of the Martin Marietta Energy Systems, Inc., Office of Technology Applications.

[d]Estimated.

Appendix
Resource Projections

Table A.1. Laboratory funding summary[a]

($ in millions)

	FY 1983		FY 1984		FY 1985		FY 1986		FY 1987		FY 1988		FY 1989		FY 1990	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
Department of Energy Effort	268.6	269.9	284.9	280.4	278.6	292.8	332.9	323.5	340.8	335.1	350.0	343.7	349.9	350.2	354.4	354.6
Work for Others	56.4	58.7	78.4	78.4	91.5	86.4	88.8	83.4	83.3	83.7	80.2	80.8	79.8	80.4	79.6	80.2
Total Operating	325.0	328.6	363.3	358.8	370.1	379.2	421.7	406.9	424.1	418.8	430.2	424.5	429.7	430.6	434.2	434.8
Capital Equipment	23.7		21.9		24.6		20.4		33.7		40.6		51.4		33.3	
Program Construction																
Funded/Budgeted	5.0		10.5		7.1		2.7									
Proposed							18.8		31.9		45.2		56.7		90.0	
Environmental Concerns Project					16.2		35.9		99.0		153.9		93.5			
General Purpose Facilities																
Funded/Budgeted	3.6		7.3		5.6		9.2									
Proposed							6.1		25.0		63.2		20.0		10.0	
General Plant Projects (AT, AR, and WB)	7.0		8.1		9.8		12.5		18.7		25.7		25.2		23.2	
General Purpose Equipment	4.0		4.0		6.4		7.2		8.0		8.0		8.0		8.0	
Total Laboratory Funding	368.3		415.2		439.8		534.5		640.4		766.8		684.5		598.5	

[a]Escalation factors are 7%; FY 1987–FY 1990 are in constant FY 1986 dollars.

Table A.2. Laboratory personnel summary by fiscal year

(Full-time equivalents)

	1983	1984	1985	1986	1987	1988	1989	1990
Direct								
Department of Energy Effort	1579	1553	1558	1652	1688	1718	1746	1768
Work for Others	379	392	431	407	410	404	402	400
Isotopes	43	48	44	45	45	45	45	45
Total Technical	2001	1993	2033	2104	2143	2167	2193	2213
Other Direct[a]	266	253	224	238	243	243	245	245
Total Direct	2267	2246	2257	2342	2386	2410	2438	2458
Indirect	2442	2497	2514	2568	2615	2644	2676	2700
Total Laboratory Personnel	4709	4743	4771	4910	5001	5054	5114	5158

[a]Includes Computing and Telecommunications, Engineering, Y-12, and Oak Ridge Gaseous Diffusion personnel charged to Oak Ridge National Laboratory. The addition of the Other Direct category represents a change in accounting that will be continued at the Laboratory.

Table A.3. Funding by Assistant Secretarial Level Office
(Millions of dollars)

	FY 1984		FY 1985[a]		FY 1986[a]		FY 1987[a]		FY 1988		FY 1989		FY 1990	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
Assistant Secretary for Fossil Energy														
Total Operating	9.7	9.3	10.3	11.1	11.3	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0
Capital Equipment	0.0		0.9		0.8		0.8		0.8		0.8		0.8	
Total ASFE	9.7		11.2		12.1		11.8		11.8		11.8		11.8	
Assistant Secretary for Nuclear Energy														
Total Operating	45.6	45.0	36.6	40.1	42.3	47.8	53.4	53.4	54.7	54.7	54.7	54.7	54.7	54.7
Capital Equipment	3.7		0.9		1.1		14.1		21.3		32.3		14.3	
Total ASNE	49.3		37.6		43.4		67.6		76.0		87.0		69.0	
Assistant Secretary for Conservation and Renewable Energy														
Total Operating	35.3	30.5	42.5	44.0	52.2	47.7	56.6	51.1	58.4	52.4	52.0	52.4	52.0	52.4
Capital Equipment	0.2		6.2		2.1		2.3		2.3		2.2		2.2	
Construction	9.0		6.6		2.7		0.0		0.0		0.0		0.0	
Total ASCE	44.6		55.3		57.0		58.9		60.7		54.2		54.2	
Assistant Secretary for International Affairs and Energy Emergencies														
Total Operating	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Office of Energy Research														
Total Operating	144.5	146.1	138.7	145.5	171.9	161.9	165.6	165.5	167.5	167.3	169.0	168.9	170.5	170.4
Capital Equipment	15.7		11.7		13.0		13.6		13.5		13.4		13.3	
Construction	0.5		0.5		0.0		0.0		0.0		0.0		0.0	
Total OER	160.7		150.9		184.9		179.2		180.9		182.4		183.8	
Assistant Secretary for Defense Programs														
Total Operating	28.0	28.1	30.8	30.8	33.3	33.3	30.9	30.9	30.1	30.1	30.1	30.1	30.1	30.1
Capital Equipment	1.3		2.3		2.2		2.0		1.9		1.9		1.9	

Table A.3 (continued)

	FY 1984		FY 1985[a]		FY 1986[a]		FY 1987[a]		FY 1988		FY 1989		FY 1990	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
Construction	1.0		0.0		0.0		0.0		0.0		0.0		0.0	
Total ASDP	30.2		33.1		35.5		32.8		32.0		32.0		32.0	
Assistant Secretary for Policy, Safety, and Environment														
Total Operating	1.9	2.3	1.8	2.6	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Capital Equipment	0.1		0.0		0.0		0.0		0.0		0.0		0.0	
Total ASPSE	2.0		1.8		3.0		3.1		3.1		3.1		3.1	
Federal Energy Regulatory Commission														
Total Operating	0.5	0.5	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Economic Regulatory Administration														
Total Operating	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Energy Information Administration														
Total Operating	1.2	2.8	2.0	2.7	1.6	1.6	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Office of Civilian Radioactive Waste Management														
Total Operating	1.8	1.7	3.0	3.0	4.3	4.3	6.1	6.1	11.1	11.1	16.1	16.1	19.2	19.2
Assistant Secretary for Management and Administration														
Total Operating	1.1	1.1	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Capital Equipment	0.1		0.1		0.1		0.0		0.0		0.0		0.0	
Total ASMA	1.2		1.2		1.1		1.0		1.0		1.0		1.0	

DOE Contractors and Operations Offices														
Total Operating	15.0	13.0	11.2	11.2	11.1	11.1	11.1	11.1	11.1	11.1	11.0	11.0	11.0	11.0
Capital Equipment	0.1		0.1		0.1		0.0		0.0		0.0		0.0	
Total Program	15.1		11.3		11.2		11.1		11.1		11.0		11.0	
Total DOE Programs														
Total Operating	284.8	280.4	278.6	292.8	332.8	323.4	340.8	335.1	349.9	343.7	349.9	350.1	354.4	354.7
Capital Equipment	21.2		22.4		19.5		32.9		39.8		50.6		32.5	
Construction	10.5		7.1		2.7		0.0		0.0		0.0		0.0	
Total DOE Programs	316.5		308.1		355.0		373.7		389.7		400.5		386.9	
Department of Transportation														
Total Operating	0.3	0.3	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Federal Emergency Management Agency														
Total Operating	2.6	2.6	3.0	3.0	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
Capital Equipment	0.0		0.0		0.0		0.0		0.0		0.0		0.0	
Total FEMA	2.6		3.1		3.4		3.3		3.3		3.3		3.3	
Nuclear Regulatory Commission														
Total Operating	30.9	30.8	29.5	29.5	27.6	28.0	27.6	28.0	27.6	28.0	27.6	28.0	27.6	28.0
Capital Equipment	0.5		0.3		0.1		0.1		0.1		0.1		0.1	
Total NRC	31.3		29.8		27.7		27.7		27.7		27.7		27.7	
Department of Defense														
Total Operating	22.1	22.1	30.5	25.1	31.6	25.8	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7
Capital Equipment	0.2		1.8		0.6		0.6		0.6		0.6		0.6	
Total DOD	22.3		32.3		32.2		27.3		27.3		27.3		27.3	
Department of the Interior														
Total Operating	0.6	0.6	1.3	1.3	1.6	1.6	1.4	1.4	1.3	1.3	1.0	1.0	0.8	0.8

Table A.3 (continued)

	FY 1984		FY 1985[a]		FY 1986[a]		FY 1987[a]		FY 1988		FY 1989		FY 1990	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
Department of Health and Human Services														
Total Operating	5.8	5.8	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Environmental Protection Agency														
Total Operating	4.3	4.3	4.4	4.4	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
National Science Foundation														
Total Operating	1.8	1.8	2.2	2.2	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Capital Equipment	0.0		0.0		0.0		0.0		0.0		0.0		0.0	
Total NSF	1.8		2.3		2.5		2.5		2.5		2.5		2.5	
Tennessee Valley Authority														
Total Operating	0.3	0.3	0.6	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Other Federal Agencies														
Total Operating	3.6	3.6	5.4	5.5	2.5	2.5	2.5	2.5	2.4	2.4	2.4	2.4	2.4	2.4
Capital Equipment	0.0		0.1		0.1		0.1		0.1		0.1		0.1	
Total Federal Agencies	3.6		5.4		2.6		2.6		2.5		2.5		2.5	
Electric Power Research Institute														
Total Operating	1.9	1.9	2.9	2.7	2.7	2.7	2.2	2.2	1.3	1.5	1.3	1.3	1.3	1.3
Other Nonfederal Agencies														
Total Operating	4.4	4.4	4.3	4.8	3.8	3.8	3.9	3.9	2.0	2.0	2.0	2.0	2.0	2.0
Total Work for Others														
Total Operating	78.4	78.4	91.5	86.4	88.8	83.4	83.3	83.7	80.3	80.8	80.0	80.4	79.8	80.2
Capital Equipment	0.8		2.2		0.9		0.8		0.8		0.8		0.8	
Total WFO	79.2		93.8		89.8		84.1		81.1		80.8		80.6	

General Purpose Facilities							
Facilities (GPF)	7.3	5.6	9.2				
General Plant Project	8.1	9.8	12.5	18.7	25.7	25.2	23.2
General Purpose Equipment	4.0	6.4	7.2	8.0	8.0	8.0	8.0
Proposed Construction			18.8	31.9	45.2	56.7	90.0
Proposed GPF			6.1	25.0	63.2	20.0	10.0
Proposed ECP[b]		16.2	35.9	99.0	153.9	93.5	
Total Laboratory funding	415.2	439.8	534.5	640.4	766.8	684.5	598.5

[a] Escalation factors from FY 1984 to FY 1985 and from FY 1985 to FY 1986 are both 7.0%. Figures for FY 1987 through FY 1990 are in constant FY 1986 dollars.
[b] Proposed Environmental Concerns Project

Table A.4. Personnel by Assistant Secretarial Level Office
(Full-time equivalents)

	FY 1984	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990
Assistant Secretary for Fossil Energy							
Technical	45.1	49.1	50.0	50.0	50.0	50.0	50.0
Other Direct	1.4	2.0	2.2	2.2	2.2	2.2	2.2
Total Direct	46.5	51.1	52.2	52.2	52.2	52.2	52.2
Assistant Secretary for Nuclear Energy							
Technical	216.0	237.0	270.8	285.1	291.4	289.4	289.4
Other Direct	85.6	26.0	31.9	35.8	36.0	38.0	38.0
Total Direct	301.6	263.0	302.7	320.9	327.4	327.4	327.4
Assistant Secretary for Conservation and Renewable Energy							
Technical	112.9	131.2	132.1	130.9	128.9	128.9	128.9
Other Direct	11.5	6.2	5.9	5.9	5.9	5.9	5.9
Total Direct	124.4	137.4	138.0	136.8	134.8	134.8	134.8
Assistant Secretary for International Affairs and Energy Emergencies							
Technical	0.5	0.3	0.0	0.0	0.0	0.0	0.0
Other Direct	0.3	0.2	0.0	0.0	0.0	0.0	0.0
Total Direct	0.8	0.5	0.0	0.0	0.0	0.0	0.0
Office of Energy Research							
Technical	790.2	845.1	883.8	900.6	913.1	924.6	934.6
Other Direct	220.2	115.7	132.3	135.1	135.1	135.1	135.1
Total Direct	1010.4	960.8	1016.1	1035.7	1048.2	1059.7	1069.7

Assistant Secretary for Defense Programs							
Technical	131.2	180.0	198.6	197.7	191.7	191.7	191.7
Other Direct	55.4	18.3	13.9	13.0	13.0	13.0	13.0
Total Direct	186.6	198.3	212.5	210.7	204.7	204.7	204.7
Assistant Secretary for Policy, Safety, and Environment							
Technical	12.2	12.0	13.0	13.0	13.0	13.0	13.0
Other Direct	2.2	2.0	2.0	2.0	2.0	2.0	2.0
Total Direct	14.4	14.0	15.0	15.0	15.0	15.0	15.0
Federal Energy Regulatory Commission							
Technical	3.2	4.7	4.7	4.7	4.7	4.7	4.7
Other Direct	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Direct	3.2	4.7	4.7	4.7	4.7	4.7	4.7
Economic Regulatory Administration							
Technical	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Direct	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Direct	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Energy Information Administration							
Technical	10.1	8.3	5.7	5.7	5.7	5.7	5.7
Other Direct	0.5	0.6	0.5	0.5	0.5	0.5	0.5
Total Direct	10.6	8.9	6.2	6.2	6.2	6.2	6.2
Office of Civilian Radioactive Waste Management							
Technical	7.0	13.1	17.2	24.7	44.2	63.7	75.2
Other Direct	1.7	2.0	2.5	2.5	2.5	2.5	2.5
Total Direct	8.7	15.1	19.7	27.2	46.7	66.2	77.7
Assistant Secretary for Management and Administration							
Technical	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Other Direct	5.7	8.7	8.7	8.7	8.7	8.7	8.7
Total Direct	5.9	8.7	8.7	8.7	8.7	8.7	8.7

Table A.4 (continued)

	FY 1984	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990
DOE Contractors and Operations Offices							
Technical	70.8	77.0	75.8	75.5	75.5	74.5	74.5
Other Direct	21.9	1.2	1.2	1.2	1.2	1.2	1.2
Total Direct	92.7	78.2	77.0	76.7	76.7	75.7	75.7
Total DOE Programs							
Technical	1399.4	1557.8	1651.7	1687.9	1718.2	1746.2	1767.7
Other Direct	406.4	182.9	201.1	206.9	207.1	209.1	209.1
Total Direct	1805.8	1740.7	1852.8	1894.8	1925.3	1955.3	1976.8
Department of Transportation							
Technical	1.3	2.3	3.4	3.4	3.4	3.4	3.4
Other Direct	1.0	0.5	0.5	0.5	0.5	0.5	0.5
Total Direct	2.3	2.8	3.9	3.9	3.9	3.9	3.9
Federal Emergency Management Agency							
Technical	11.7	14.0	15.0	15.0	15.0	15.0	15.0
Other Direct	4.8	5.0	5.0	5.0	5.0	5.0	5.0
Total Direct	16.5	19.0	20.0	20.0	20.0	20.0	20.0
Nuclear Regulatory Commission							
Technical	139.9	168.1	145.2	145.2	145.2	145.2	145.2
Other Direct	21.9	15.6	14.8	14.8	14.8	14.8	14.8
Total Direct	161.8	183.7	160.0	160.0	160.0	160.0	160.0
Department of Defense							
Technical	61.5	83.7	85.5	90.5	90.5	90.5	90.5
Other Direct	5.4	9.4	9.0	8.9	8.9	8.9	8.9
Total Direct	66.9	93.1	94.5	99.4	99.4	99.4	99.4

Department of the Interior							
Technical	2.6	10.7	12.3	10.3	9.3	7.3	5.3
Other Direct	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Direct	2.6	10.7	12.3	10.3	9.3	7.3	5.3
Department of Health and Human Services							
Technical	53.1	59.0	59.0	59.0	59.0	59.0	59.0
Other Direct	0.4	1.0	1.0	1.0	1.0	1.0	1.0
Total Direct	53.5	60.0	60.0	60.0	60.0	60.0	60.0
Environmental Protection Agency							
Technical	28.1	29.0	29.0	29.0	29.0	29.0	29.0
Other Direct	0.2	1.0	1.0	1.0	1.0	1.0	1.0
Total Direct	28.3	30.0	30.0	30.0	30.0	30.0	30.0
National Science Foundation							
Technical	8.7	12.0	12.0	12.0	12.0	12.0	12.0
Other Direct	2.7	1.3	1.5	1.5	1.5	1.5	1.5
Total Direct	11.4	13.3	13.5	13.5	13.5	13.5	13.5
Tennessee Valley Authority							
Technical	2.0	5.6	4.9	4.9	4.9	4.9	4.9
Other Direct	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Direct	2.0	5.6	4.9	4.9	4.9	4.9	4.9
Other Federal Agencies							
Technical	9.0	18.0	14.6	14.4	13.4	13.4	13.4
Other Direct	1.9	3.6	2.4	2.0	2.0	2.0	2.0
Total Direct	10.9	21.6	17.0	16.4	15.4	15.4	15.4
Electric Power Research Institute							
Technical	11.5	8.8	7.7	7.7	7.7	7.7	7.7
Other Direct	0.8	1.0	1.0	1.0	1.0	1.0	1.0
Total Direct	12.3	9.8	8.7	8.7	8.7	8.7	8.7

Table A.4 (continued)

	FY 1984	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990
Other Nonfederal Agencies							
Technical	18.5	20.1	18.6	18.8	14.7	14.7	14.7
Other Direct	5.1	2.8	0.5	0.5	0.0	0.0	0.0
Total Direct	23.6	22.9	19.1	19.3	14.7	14.7	14.7
Total Work for Others							
Technical	347.9	431.3	407.2	410.2	404.1	402.1	400.1
Other Direct	44.2	41.2	36.7	36.2	35.7	35.7	35.7
Total Direct	392.1	472.5	443.9	446.4	439.8	437.8	435.8
Total Direct							
Technical	1747.3	1989.1	2058.9	2098.1	2122.3	2148.3	2167.8
Other Direct	450.6	224.1	237.8	243.1	242.8	244.8	244.8
Total Direct	2197.9	2213.2	2296.7	2341.2	2365.1	2393.1	2412.6
Isotopes	48.0	44.0	45.0	45.0	45.0	45.0	45.0
Total Indirect	2497.0	2514.0	2568.0	2615.0	2644.0	2676.0	2700.0
Total Laboratory	4743.0	4771.0	4910.0	5001.0	5054.0	5114.0	5158.0

Table A.5. Resources by major program

	FY 1984		FY 1985[a]		FY 1986[a]		FY 1987[a]		FY 1988		FY 1989		FY 1990	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
Assistant Secretary for Fossil Energy														
AA—Coal														
Total Operating	9.5	9.2	10.1	10.9	11.2	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8
Capital Equipment	.0		.9		.8		.8		.8		.8		.8	
Total Program	9.5		11.0		11.9		11.6		11.6		11.6		11.6	
Technical Personnel	44.6		48.2		49.1		49.1		49.1		49.1		49.1	
Other Direct Personnel	1.4		2.0		2.2		2.2		2.2		2.2		2.2	
Total Direct Personnel	46.0		50.2		51.3		51.3		51.3		51.3		51.3	
AB—Gas														
Total Operating	.0	.1	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2
Technical Personnel	.4		.9		.9		.9		.9		.9		.9	
Other Direct Personnel	.0		.0		.0		.0		.0		.0		.0	
Total Direct Personnel	.4		.9		.9		.9		.9		.9		.9	
CH—Alternate Fuels Production														
Total Operating	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Technical Personnel	.1		.0		.0		.0		.0		.0		.0	
Other Direct Personnel	.0		.0		.0		.0		.0		.0		.0	
Total Direct Personnel	.1		.0		.0		.0		.0		.0		.0	
Assistant Secretary for Fossil Energy														
Total Operating	9.7	9.3	10.3	11.1	11.3	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0
Capital Equipment	.0		.9		.8		.8		.8		.8		.8	
Total ASFE	9.7		11.2		12.1		11.8		11.8		11.8		11.8	
Technical Personnel	45.1		49.1		50.0		50.0		50.0		50.0		50.0	
Other Direct Personnel	1.4		2.0		2.2		2.2		2.2		2.2		2.2	
Total Direct Personnel	46.5		51.1		52.2		52.2		52.2		52.2		52.2	

Table A.5 (continued)

	FY 1984		FY 1985[a]		FY 1986[a]		FY 1987[a]		FY 1988		FY 1989		FY 1990	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
Assistant Secretary for Nuclear Energy														
AE—Advanced Nuclear Systems														
Total Operating	2.2	2.1	1.7	1.7	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1
Capital Equipment	.1		.2		.2		.2		.2		.2		.2	
Total Program	2.3		1.9		4.3		4.3		4.3		4.3		4.3	
Technical Personnel	12.0		9.5		20.7		20.7		20.7		20.7		20.7	
Other Direct Personnel	1.1		.0		.2		.2		.2		.2		.2	
Total Direct Personnel	13.1		9.5		20.9		20.9		20.9		20.9		20.9	
AF—Breeder Reactor Systems														
Total Operating	10.0	10.6	9.7	9.7	10.4	10.4	10.4	10.4	10.4	10.4	10.4	10.4	10.4	10.4
Capital Equipment	.1		.1		.0		.0		.0		.0		.0	
Total Program	10.1		9.8		10.5		10.4		10.4		10.4		10.4	
Technical Personnel	59.1		55.0		55.0		55.0		55.0		55.0		55.0	
Other Direct Personnel	14.2		7.2		7.2		7.2		7.2		7.2		7.2	
Total Direct Personnel	73.3		62.2		62.2		62.2		62.2		62.2		62.2	
AG—Converter Reactor Systems														
Total Operating	5.0	5.0	5.6	5.6	6.7	6.7	7.4	7.4	8.4	8.4	8.4	8.4	8.4	8.4
Capital Equipment	.4		.5		.7		.8		1.0		2.0		2.0	
Total Program	5.4		6.1		7.4		8.2		9.4		10.4		10.4	
Technical Personnel	25.7		30.9		35.6		38.6		43.6		41.6		41.6	
Other Direct Personnel	5.4		1.0		1.6		2.0		2.0		4.0		4.0	
Total Direct Personnel	31.1		31.9		37.2		40.6		45.6		45.6		45.6	
AH—Remedial Action Programs														
Total Operating	2.9	3.2	3.6	3.6	4.9	4.9	4.9	4.9	5.2	5.2	5.2	5.2	5.2	5.2
Capital Equipment	.0		.1		.2		.1		.0		.0		.0	
Total Program	2.9		3.7		5.1		5.1		5.3		5.3		5.3	
Technical Personnel	19.6		29.1		40.1		41.2		43.5		43.5		43.5	
Other Direct Personnel	3.9		2.0		.6		.8		1.0		1.0		1.0	
Total Direct Personnel	23.5		31.1		40.7		42.0		44.5		44.5		44.5	

AP—Commercial Nuclear Waste Management																
Total Operating	.4	.4	.4	.4	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2		
Capital Equipment	.1		.0		.0		.0		.0		.0		.0			
Total Program	.5		.4		.2		.2		.2		.2		.2			
Technical Personnel	2.2		2.2		1.1		1.1		1.1		1.1		1.1			
Other Direct Personnel	.0		.1		.1		.1		.1		.1		.1			
Total Direct Personnel	2.2		2.3		1.2		1.2		1.2		1.2		1.2			
AS—Nuclear Fuel Cycle																
Total Operating	24.8	23.3	15.6	19.0	16.0	21.5	26.4	26.4	26.4	26.4	26.4	26.4	26.4	26.4		
Capital Equipment	3.0		.0		.0		13.0		20.0		30.0		12.0			
Total Program	27.8		15.6		16.0		39.4		46.4		56.4		38.4			
Technical Personnel	96.9		110.3		118.3		128.5		127.5		127.5		127.5			
Other Direct Personnel	61.0		15.7		22.2		25.5		25.5		25.5		25.5			
Total Direct Personnel	157.9		126.0		140.5		154.0		153.0		153.0		153.0			
CD—Uranium Enrichment																
Total Operating	.3	.3	.0	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0		
Technical Personnel	.5		.0		.0		.0		.0		.0		.0			
Other Direct Personnel	.0		.0		.0		.0		.0		.0		.0			
Total Direct Personnel	.5		.0		.0		.0		.0		.0		.0			
Assistant Secretary for Nuclear Energy																
Total Operating	45.6	45.0	36.6	40.1	42.3	47.8	53.4	53.4	54.7	54.7	54.7	54.7	54.7	54.7		
Capital Equipment	3.7		.9		1.1		14.1		21.3		32.3		14.3			
Total ASNE	49.3		37.6		43.4		67.6		76.0		87.0		69.0			
Technical Personnel	216.0		237.0		270.8		285.1		291.4		289.4		289.4			
Other Direct Personnel	85.6		26.0		31.9		35.8		36.0		38.0		38.0			
Total Direct Personnel	301.6		263.0		302.7		320.9		327.4		327.4		327.4			
Assistant Secretary for Conservation and Renewable Energy																
AK—Electric Energy Systems																
Total Operating	5.2	6.5	6.4	7.6	6.9	7.0	6.9	6.7	6.9	6.7	6.9	6.7	6.9	6.7		
Capital Equipment	-.2		.1		.1		.1		.1		.1		.1			

Table A.5 (continued)

	FY 1984		FY 1985[a]		FY 1986[a]		FY 1987[a]		FY 1988		FY 1989		FY 1990	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
Total Program	5.0		6.5		7.0		7.0		7.0		7.0		7.0	
Technical Personnel	16.0		19.3		19.3		19.3		19.3		19.3		19.3	
Other Direct Personnel	3.6		2.0		2.0		2.0		2.0		2.0		2.0	
Total Direct Personnel	19.6		21.3		21.3		21.3		21.3		21.3		21.3	
AL—Energy Storage Systems														
Total Operating	1.7	2.1	1.3	1.4	2.2	1.7	2.2	2.2	2.0	2.0	2.0	2.0	2.0	2.0
Capital Equipment	.0		.1		.0		.0		.0		.0		.0	
Total Program	1.7		1.4		2.3		2.3		2.1		2.1		2.1	
Technical Personnel	7.1		7.0		7.0		5.7		3.7		3.7		3.7	
Other Direct Personnel	.1		.3		.3		.3		.3		.3		.3	
Total Direct Personnel	7.2		7.3		7.3		6.0		4.0		4.0		4.0	
AM—Geothermal														
Total Operating	.0	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
Technical Personnel	.2		.8		.8		.8		.8		.8		.8	
Other Direct Personnel	.0		.0		.0		.0		.0		.0		.0	
Total Direct Personnel	.2		.8		.8		.8		.8		.8		.8	
CC—Geothermal														
Total Operating	.1	.1	.1	.1	.2	.1	.2	.2	.2	.2	.2	.2	.2	.2
Technical Personnel	.3		.9		.9		.9		.9		.9		.9	
Other Direct Personnel	.0		.0		.0		.0		.0		.0		.0	
Total Direct Personnel	.3		.9		.9		.9		.9		.9		.9	
CE—Hydropower														
Total Operating	.0	.2	.0	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Technical Personnel	.3		.0		.0		.0		.0		.0		.0	
Other Direct Personnel	.0		.0		.0		.0		.0		.0		.0	
Total Direct Personnel	.3		.0		.0		.0		.0		.0		.0	

Table A.5 (continued)

	FY 1984		FY 1985[a]		FY 1986[a]		FY 1987[a]		FY 1988		FY 1989		FY 1990	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
EB—Solar Energy														
Total Operating	6.0	3.9	7.7	6.2	8.2	7.7	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2
Technical Personnel	14.1		13.9		14.5		14.5		14.5		14.5		14.5	
Other Direct Personnel	.3		.4		.4		.4		.4		.4		.4	
Total Direct Personnel	14.4		14.3		14.9		14.9		14.9		14.9		14.9	
EC—Buildings and Community Systems														
Total Operating	11.4	9.9	12.7	13.7	13.4	13.6	13.6	13.6	13.6	13.6	13.6	13.6	13.6	13.6
Capital Equipment	.4		2.9		.8		.8		.8		.8		.8	
Total Program	11.9		15.6		14.2		14.4		14.4		14.4		14.4	
Technical Personnel	40.4		45.1		41.5		39.7		39.7		39.7		39.7	
Other Direct Personnel	5.9		2.8		2.5		2.5		2.5		2.5		2.5	
Total Direct Personnel	46.3		47.9		44.0		42.2		42.2		42.2		42.2	
ED—Industrial														
Total Operating	1.5	1.1	1.7	1.8	1.8	2.0	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Capital Equipment	.0		.4		.1		.1		.1		.1		.1	
Total Program	1.5		2.1		1.9		1.9		1.9		1.9		1.9	
Technical Personnel	7.3		10.5		10.5		10.5		10.5		10.5		10.5	
Other Direct Personnel	.6		.5		.5		.5		.5		.5		.5	
Total Direct Personnel	7.9		11.0		11.0		11.0		11.0		11.0		11.0	
EE—Transportation														
Total Operating	6.4	3.2	6.4	7.6	10.9	7.7	15.2	9.8	17.2	11.3	10.8	11.3	10.8	11.3
Capital Equipment	.0		2.0		.4		.6		.6		.5		.5	
Construction	9.0		6.6		2.7		.0		.0		.0		.0	
Total Program	15.4		15.0		14.0		15.8		17.8		11.3		11.3	
Technical Personnel	15.0		16.0		18.0		20.0		20.0		20.0		20.0	
Other Direct Personnel	.9		.0		.0		.0		.0		.0		.0	
Total Direct Personnel	15.9		16.0		18.0		20.0		20.0		20.0		20.0	

Table A.5 (continued)

	FY 1984		FY 1985[a]		FY 1986[a]		FY 1987[a]		FY 1988		FY 1989		FY 1990	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
EF—State/Local Programs														
Total Operating	.5	.5	.6	.7	.6	.6	.6	.6	.6	.6	.6	.6	.6	.6
Technical Personnel	2.1		3.7		2.9		2.8		2.8		2.8		2.8	
Other Direct Personnel	.0		.0		.0		.0		.0		.0		.0	
Total Direct Personnel	2.1		3.7		2.9		2.8		2.8		2.8		2.8	
EG—Multisector														
Total Operating	2.5	2.8	5.4	4.6	7.9	7.1	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9
Capital Equipment	.0		.6		.6		.6		.6		.6		.6	
Total Program	2.5		6.1		8.6		8.6		8.6		8.6		8.6	
Technical Personnel	10.1		14.0		16.7		16.7		16.7		16.7		16.7	
Other Direct Personnel	.1		.2		.2		.2		.2		.2		.2	
Total Direct Personnel	10.2		14.2		16.9		16.9		16.9		16.9		16.9	
Assistant Secretary for Conservation and Renewable Energy														
Total Operating	35.3	30.5	42.5	44.0	52.2	47.7	56.6	51.1	58.4	52.4	52.0	52.4	52.0	52.4
Capital Equipment	.2		6.2		2.1		2.3		2.3		2.2		2.2	
Construction	9.0		6.6		2.7		.0		.0		.0		.0	
Total ASCE	44.6		55.3		57.0		58.9		60.7		54.2		54.2	
Technical Personnel	112.9		131.2		132.1		130.9		128.9		128.9		128.9	
Other Direct Personnel	11.5		6.2		5.9		5.9		5.9		5.9		5.9	
Total Direct Personnel	124.4		137.4		138.0		136.8		134.8		134.8		134.8	
Assistant Secretary for International Affairs and Energy Emergencies														
UB—Utility Programs and Regulatory Intervention														
Total Operating	.0	.1	.0	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Technical Personnel	.5		.3		.0		.0		.0		.0		.0	
Other Direct Personnel	.3		.2		.0		.0		.0		.0		.0	
Total Direct Personnel	.8		.5		.0		.0		.0		.0		.0	

UE—Fuels Regulation

Total Operating	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Technical Personnel	.0		.0		.0		.0		.0		.0		.0		.0		.0		.0	
Other Direct Personnel	.0		.0		.0		.0		.0		.0		.0		.0		.0		.0	
Total Direct Personnel	.0		.0		.0		.0		.0		.0		.0		.0		.0		.0	

Assistant Secretary for International Affairs and Energy Emergencies

Total Operating	.0	.1	.0	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Technical Personnel	.5		.3		.0		.0		.0		.0		.0		.0		.0		.0	
Other Direct Personnel	.3		.2		.0		.0		.0		.0		.0		.0		.0		.0	
Total Direct Personnel	.8		.5		.0		.0		.0		.0		.0		.0		.0		.0	

Office of Energy Research

AT—Magnetic Fusion

Total Operating	57.7	58.4	51.1	54.4	64.6	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0
Capital Equipment	8.0		3.7		3.7		3.6		3.6		3.6		3.6		3.6		3.6		3.6	
Total Program	65.7		54.8		68.3		58.6		58.6		58.6		58.6		58.6		58.6		58.6	
Technical Personnel	170.2		172.5		173.7		177.3		177.3		177.3		177.3		177.3		177.3		177.3	
Other Direct Personnel	133.7		98.0		102.4		104.7		104.7		104.7		104.7		104.7		104.7		104.7	
Total Direct Personnel	303.9		270.5		276.1		282.0		282.0		282.0		282.0		282.0		282.0		282.0	

HA—Environmental Research and Development

Total Operating	28.2	28.6	25.8	29.3	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0
Capital Equipment	1.5		1.4		1.7		2.0		2.0		2.0		2.0		2.0		2.0		2.0	
Total Program	29.7		27.2		33.7		34.0		34.0		34.0		34.0		34.0		34.0		34.0	
Proposed Construction	.0		.0		6.2		10.2		29.6		1.7		.0							
Technical Personnel	182.8		190.0		200.0		200.0		200.0		200.0		200.0							
Other Direct Personnel	11.1		7.0		8.0		8.0		8.0		8.0		8.0							
Total Direct Personnel	193.9		197.0		208.0		208.0		208.0		208.0		208.0							

Table A.5 (continued)

	FY 1984		FY 1985[a]		FY 1986[a]		FY 1987[a]		FY 1988		FY 1989		FY 1990	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
KA—High Energy Physics														
Total Operating	.6	.6	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5
Technical Personnel	4.0		2.6		2.6		2.6		2.6		2.6		2.6	
Other Direct Personnel	.9		1.1		1.1		1.1		1.1		1.1		1.1	
Total Direct Personnel	4.9		3.7		3.7		3.7		3.7		3.7		3.7	
KB—Nuclear Physics														
Total Operating	9.6	9.6	9.9	10.0	11.2	11.0	11.4	11.3	11.8	11.7	12.3	12.2	12.7	12.6
Capital Equipment	1.3		1.1		1.3		1.4		1.4		1.4		1.4	
Total Program	10.9		11.1		12.5		12.8		13.2		13.7		13.7	
Proposed Construction	.0		.0		.5		.6		.0		.0		.0	
Technical Personnel	61.3		71.2		77.4		79.0		82.0		85.5		88.5	
Other Direct Personnel	15.5		2.4		1.5		1.5		1.5		1.5		1.5	
Total Direct Personnel	76.8		73.6		78.9		80.5		83.5		87.0		90.0	
KC—Basic Energy Sciences														
Total Operating	47.4	48.0	50.3	50.3	62.1	62.1	64.8	64.8	66.2	66.2	67.3	67.3	68.4	68.4
Capital Equipment	4.9		5.5		6.2		6.5		6.4		6.3		6.2	
Construction	.5		.5		.0		.0		.0		.0		.0	
Total Program	52.8		56.3		68.4		71.4		72.6		73.6		74.6	
Proposed Construction	.0		.0		11.1		14.6		15.6		55.0		90.0	
Technical Personnel	367.3		402.8		422.1		433.7		443.2		451.2		458.2	
Other Direct Personnel	59.0		7.2		19.3		19.8		19.8		19.8		19.8	
Total Direct Personnel	426.3		410.0		441.4		453.5		463.0		471.0		478.0	
KD—Energy Research and Analysis														
Total Operating	1.0	.6	.6	.6	.6	.6	.6	.6	.6	.6	.6	.6	.6	.6
Technical Personnel	3.1		3.0		3.0		3.0		3.0		3.0		3.0	
Other Direct Personnel	.0		.0		.0		.0		.0		.0		.0	
Total Direct Personnel	3.1		3.0		3.0		3.0		3.0		3.0		3.0	

KE—University Research Support

Total Operating	.1	.2	.5	.4	.9	.8	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Capital Equipment	.0		.0		.1		.1		.1		.1		.1	
Total Program	.1		.5		1.0		1.4		1.4		1.4		1.4	
Technical Personnel	1.5		3.0		5.0		5.0		5.0		5.0		5.0	
Other Direct Personnel	.0		.0		.0		.0		.0		.0		.0	
Total Direct Personnel	1.5		3.0		5.0		5.0		5.0		5.0		5.0	

Office of Energy Research

Total Operating	144.5	146.1	138.7	145.5	171.9	161.9	165.6	165.5	167.4	167.3	169.0	168.9	170.5	170.4
Capital Equipment	15.7		11.7		13.0		13.6		13.5		13.4		13.3	
Construction	.5		.5		.0		.0		.0		.0		.0	
Total OER	160.7		150.9		184.9		179.2		180.9		182.4		183.8	
Proposed Construction	.0		.0		17.8		25.4		45.2		56.7		90.0	
Technical Personnel	790.2		845.1		883.8		900.6		913.1		924.6		934.6	
Other Direct Personnel	220.2		115.7		132.3		135.1		135.1		135.1		135.1	
Total Direct Personnel	1010.4		960.8		1016.1		1035.7		1048.2		1059.7		1069.7	

Assistant Secretary for Defense Programs

AR—Defense Waste Management

Total Operating	20.5	21.0	22.3	22.3	24.4	24.4	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0
Capital Equipment	1.1		2.0		1.8		1.6		1.5		1.5		1.5	
Construction	1.0		.0		.0		.0		.0		.0		.0	
Total Program	22.6		24.3		26.2		27.6		27.5		27.5		27.5	
Proposed Construction	.0		.0		1.0		6.5		.0		.0		.0	
Technical Personnel	107.4		135.3		148.0		159.5		159.5		159.5		159.5	
Other Direct Personnel	38.5		15.0		12.5		12.5		12.5		12.5		12.5	
Total Direct Personnel	145.9		150.3		160.5		172.0		172.0		172.0		172.0	

GC—Verification and Control Technology

Total Operating	.2	.2	.3	.3	.3	.3	.4	.4	.4	.4	.4	.4	.4	.4
Capital Equipment	.0		.2		.3		.3		.3		.3		.3	
Total Program	.2		.5		.6		.6		.6		.6		.6	
Technical Personnel	2.1		2.2		2.2		2.2		2.2		2.2		2.2	
Other Direct Personnel	.0		.0		.0		.0		.0		.0		.0	
Total Direct Personnel	2.1		2.2		2.2		2.2		2.2		2.2		2.2	

Table A.5 (continued)

	FY 1984		FY 1985[a]		FY 1986[a]		FY 1987[a]		FY 1988		FY 1989		FY 1990	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
GE—Materials Production														
Total Operating	7.3	7.0	8.2	8.2	8.6	8.6	4.5	4.5	3.8	3.8	3.8	3.8	3.8	3.8
Capital Equipment	.1		.1		.2		.1		.1		.1		.1	
Total Program	7.4		8.3		8.8		4.6		3.9		3.9		3.9	
Technical Personnel	21.7		42.5		48.4		36.0		30.0		30.0		30.0	
Other Direct Personnel	16.9		3.3		1.4		.5		.5		.5		.5	
Total Direct Personnel	38.6		45.8		49.8		36.5		30.5		30.5		30.5	
Assistant Secretary for Defense Programs														
Total Operating	28.0	28.1	30.8	30.8	33.3	33.3	30.9	30.9	30.1	30.1	30.1	30.1	30.1	30.1
Capital Equipment	1.3		2.3		2.2		2.0		1.9		1.9		1.9	
Construction	1.0		.0		.0		.0		.0		.0		.0	
Total ASDP	30.2		33.1		35.5		32.8		32.0		32.0		32.0	
Proposed Construction	.0		.0		1.0		6.5		.0		.0		.0	
Technical Personnel	131.2		180.0		198.6		197.7		191.7		191.7		191.7	
Other Direct Personnel	55.4		18.3		13.9		13.0		13.0		13.0		13.0	
Total Direct Personnel	186.6		198.3		212.5		210.7		204.7		204.7		204.7	
Assistant Secretary for Policy, Safety, Environment														
EF—State and Local Programs														
Total Operating	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Technical Personnel	.0		.0		.0		.0		.0		.0		.0	
Other Direct Personnel	.0		.0		.0		.0		.0		.0		.0	
Total Direct Personnel	.0		.0		.0		.0		.0		.0		.0	
HA—Environmental Research and Development														
Total Operating	1.8	2.2	1.8	2.6	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Capital Equipment	.1		.0		.0		.0		.0		.0		.0	

Total Program	1.9		1.8		3.0		3.1		3.1		3.1		3.1	
Technical Personnel		11.8		12.0		13.0		13.0		13.0		13.0		13.0
Other Direct Personnel		2.2		2.0		2.0		2.0		2.0		2.0		2.0
Total Direct Personnel		14.0		14.0		15.0		15.0		15.0		15.0		15.0
PE—Policy and Evaluation														
Total Operating	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Technical Personnel		.4		.0		.0		.0		.0		.0		.0
Other Direct Personnel		.0		.0		.0		.0		.0		.0		.0
Total Direct Personnel		.4		.0		.0		.0		.0		.0		.0
Assistant Secretary for Policy, Safety, and Environment														
Total Operating	1.9	2.3	1.8	2.6	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Capital Equipment	.1		.0		.0		.0		.0		.0		.0	
Total ASPSE	2.0		1.8		3.0		3.1		3.1		3.1		3.1	
Technical Personnel		12.2		12.0		13.0		13.0		13.0		13.0		13.0
Other Direct Personnel		2.2		2.0		2.0		2.0		2.0		2.0		2.0
Total Direct Personnel		14.4		14.0		15.0		15.0		15.0		15.0		15.0
Federal Energy Regulatory Commission														
VI—Other Services														
Total Operating	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Technical Personnel		.0		.0		.0		.0		.0		.0		.0
Other Direct Personnel		.0		.0		.0		.0		.0		.0		.0
Total Direct Personnel		.0		.0		.0		.0		.0		.0		.0
VP—Other Expenses														
Total Operating	.5	.5	.7	.7	.8	.8	.8	.8	.8	.8	.8	.8	.8	.8
Technical Personnel		3.2		4.7		4.7		4.7		4.7		4.7		4.7
Other Direct Personnel		.0		.0		.0		.0		.0		.0		.0
Total Direct Personnel		3.2		4.7		4.7		4.7		4.7		4.7		4.7

Table A.5 (continued)

	FY 1984		FY 1985[a]		FY 1986[a]		FY 1987[a]		FY 1988		FY 1989		FY 1990	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
Federal Energy Regulatory Commission														
Total Operating	.5	.5	.7	.7	.8	.8	.8	.8	.8	.8	.8	.8	.8	.8
Technical Personnel	3.2		4.7		4.7		4.7		4.7		4.7		4.7	
Other Direct Personnel	.0		.0		.0		.0		.0		.0		.0	
Total Direct Personnel	3.2		4.7		4.7		4.7		4.7		4.7		4.7	
Economic Regulatory Administration														
UC—Compliance														
Total Operating	.0	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Technical Personnel	.0		.0		.0		.0		.0		.0		.0	
Other Direct Personnel	.0		.0		.0		.0		.0		.0		.0	
Total Direct Personnel	.0		.0		.0		.0		.0		.0		.0	
Economic Regulatory Administration														
Total Operating	.0	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Technical Personnel	.0		.0		.0		.0		.0		.0		.0	
Other Direct Personnel	.0		.0		.0		.0		.0		.0		.0	
Total Direct Personnel	.0		.0		.0		.0		.0		.0		.0	
Assistant Secretary for Management and Administration														
TA—Collection, Production and Analysis														
Total Operating	1.0	2.7	2.0	2.5	1.6	1.6	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Technical Personnel	9.3		7.3		5.7		5.7		5.7		5.7		5.7	
Other Direct Personnel	.5		.6		.5		.5		.5		.5		.5	
Total Direct Personnel	9.8		7.9		6.2		6.2		6.2		6.2		6.2	

TB—Program Services

Total Operating	.2	.1	.0	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Technical Personnel	.8		1.0		.0		.0		.0		.0		.0	
Other Direct Personnel	.0		.0		.0		.0		.0		.0		.0	
Total Direct Personnel	.8		1.0		.0		.0		.0		.0		.0	

Energy Information Administration

Total Operating	1.2	2.8	2.0	2.7	1.6	1.6	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Technical Personnel	10.1		8.3		5.7		5.7		5.7		5.7		5.7	
Other Direct Personnel	.5		.6		.5		.5		.5		.5		.5	
Total Direct Personnel	10.6		8.9		6.2		6.2		6.2		6.2		6.2	

Office of Civilian Radioactive Waste Management

DB—Nuclear Waste Fund

Total Operating	1.8	1.7	3.0	3.0	4.3	4.3	6.2	6.2	11.1	11.1	16.1	16.1	19.1	19.1
Technical Personnel	7.0		13.1		17.2		24.7		44.2		63.7		75.2	
Other Direct Personnel	1.7		2.0		2.5		2.5		2.5		2.5		2.5	
Total Direct Personnel	8.7		15.1		19.7		27.2		46.7		66.2		77.7	

Office of Civilian Radioactive Waste Management

Total Operating	1.8	1.7	3.0	3.0	4.3	4.3	6.2	6.2	11.1	11.1	16.1	16.1	19.1	19.1
Technical Personnel	7.0		13.1		17.2		24.7		44.2		63.7		75.2	
Other Direct Personnel	1.7		2.0		2.5		2.5		2.5		2.5		2.5	
Total Direct Personnel	8.7		15.1		19.7		27.2		46.7		66.2		77.7	

Assistant Secretary for Management and Administration

LA—Technical Information Services

Total Operating	1.0	1.0	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Capital Equipment	.1		.1		.1		.0		.0		.0		.0	
Total Program	1.1		1.2		1.1		1.0		1.0		1.0		1.0	
Technical Personnel	.0		.0		.0		.0		.0		.0		.0	
Other Direct Personnel	5.7		8.7		8.7		8.7		8.7		8.7		8.7	
Total Direct Personnel	5.7		8.7		8.7		8.7		8.7		8.7		8.7	

Table A.5 (continued)

	FY 1984		FY 1985[a]		FY 1986[a]		FY 1987[a]		FY 1988		FY 1989		FY 1990	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
WB—In-House Energy Management														
Total Operating	.1	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Technical Personnel	.2		.0		.0		.0		.0		.0		.0	
Other Direct Personnel	.0		.0		.0		.0		.0		.0		.0	
Total Direct Personnel	.2		.0		.0		.0		.0		.0		.0	
Assistant Secretary for Management and Administration														
Total Operating	1.1	1.1	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Capital Equipment	.1		.1		.1		.0		.0		.0		.0	
Total ASMA	1.2		1.2		1.1		1.0		1.0		1.0		1.0	
Technical Personnel	.2		.0		.0		.0		.0		.0		.0	
Other Direct Personnel	5.7		8.7		8.7		8.7		8.7		8.7		8.7	
Total Direct Personnel	5.9		8.7		8.7		8.7		8.7		8.7		8.7	
LD														
Total Operating	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Technical Personnel	.0		.0		.0		.0		.0		.0		.0	
Other Direct Personnel	.0		.0		.0		.0		.0		.0		.0	
Total Direct Personnel	.0		.0		.0		.0		.0		.0		.0	
DOE Contractors and Operations Office														
Total Operating	15.0	13.0	11.2	11.2	11.1	11.1	11.1	11.1	11.1	11.1	11.0	11.0	11.0	11.0
Capital Equipment	.1		.1		.1		.0		.0		.0		.0	
Total Program	15.1		11.3		11.2		11.1		11.1		11.0		11.0	
Technical Personnel	70.8		77.0		75.8		75.5		75.5		74.5		74.5	
Other Direct Personnel	21.9		1.2		1.2		1.2		1.2		1.2		1.2	
Total Direct Personnel	92.7		78.2		77.0		76.7		76.7		75.7		75.7	

Total DOE Programs

Total Operating	284.9	280.4	278.6	292.8	332.8	323.4	340.8	335.1	349.9	343.7	349.9	350.1	354.4	354.7
Capital Equipment	21.2		22.4		19.5		32.9		39.8		50.6		32.5	
Construction	10.5		7.1		2.7		.0		.0		.0		.0	
Total Program	316.6		308.1		355.0		373.7		389.7		400.5		386.9	
Proposed Construction	.0		.0		18.8		31.9		45.2		56.7		90.0	
Technical Personnel	1399.4		1557.8		1651.7		1687.9		1718.2		1746.2		1767.7	
Other Direct Personnel	406.4		182.9		201.1		206.9		207.1		209.1		209.1	
Total Direct Personnel	1805.8		1740.7		1852.8		1894.8		1925.3		1955.3		1976.8	

Work for Others

Department of Transportation

Total Operating	.3	.3	.4	.4	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5
Technical Personnel	1.3		2.3		3.4		3.4		3.4		3.4		3.4	
Other Direct Personnel	1.0		.5		.5		.5		.5		.5		.5	
Total Direct Personnel	2.3		2.8		3.9		3.9		3.9		3.9		3.9	

Federal Emergency Management Agency

Total Operating	2.6	2.6	3.0	3.0	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
Capital Equipment	.0		.0		.0		.0		.0		.0		.0	
Total Program	2.6		3.1		3.3		3.3		3.3		3.3			
Technical Personnel	11.7		14.0		15.0		15.0		15.0		15.0		15.0	
Other Direct Personnel	4.8		5.0		5.0		5.0		5.0		5.0		5.0	
Total Direct Personnel	16.5		19.0		20.0		20.0		20.0		20.0		20.0	

Nuclear Regulatory Commission

Total Operating	30.9	30.8	29.5	29.5	27.6	28.0	27.6	28.0	27.6	28.0	27.6	28.0	27.6	28.0
Capital Equipment	.5		.3		.1		.1		.1		.1		.1	
Total Program	31.3		29.8		27.7		27.7		27.7		27.7		27.7	
Technical Personnel	139.9		168.1		145.2		145.2		145.2		145.2		145.2	
Other Direct Personnel	21.9		15.6		14.8		14.8		14.8		14.8		14.8	
Total Direct Personnel	161.8		183.7		160.0		160.0		160.0		160.0		160.0	

Table A.5 (continued)

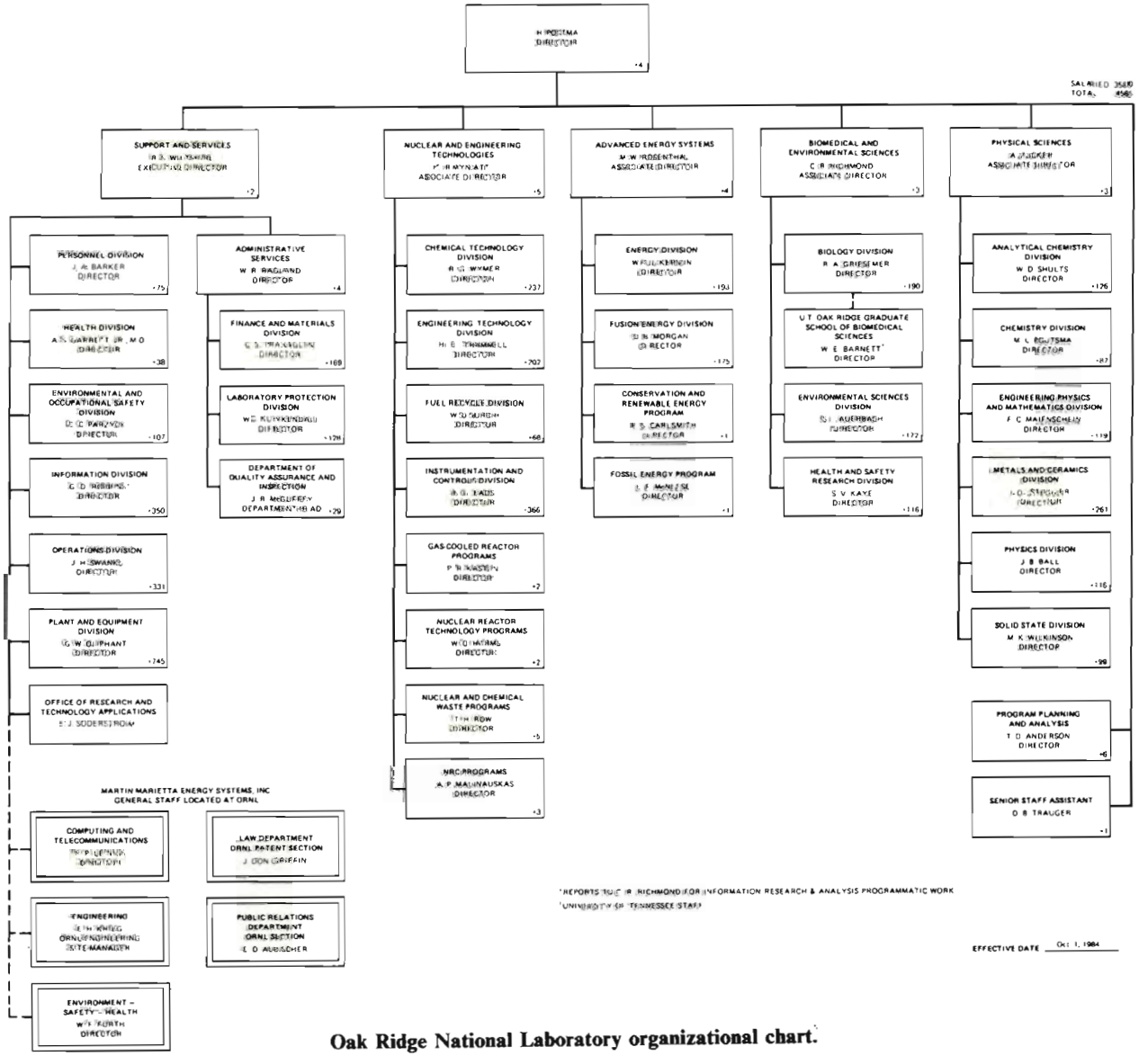
	FY 1984		FY 1985[a]		FY 1986[a]		FY 1987[a]		FY 1988		FY 1989		FY 1990	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
Department of Defense														
Total Operating	22.1	22.1	30.5	25.1	31.6	25.8	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7
Capital Equipment	.2		1.8		.6		.6		.6		.6		.6	
Total Program	22.3		32.3		32.2		27.3		27.3		27.3		27.3	
Technical Personnel	61.5		83.7		85.5		90.5		90.5		90.5		90.5	
Other Direct Personnel	5.4		9.4		9.0		8.9		8.9		8.9		8.9	
Total Direct Personnel	66.9		93.1		94.5		99.4		99.4		99.4		99.4	
Department of the Interior														
Total Operating	.6	.6	1.3	1.3	1.6	1.6	1.4	1.4	1.3	1.3	1.0	1.0	.8	.8
Technical Personnel	2.6		10.7		12.3		10.3		9.3		7.3		5.3	
Other Direct Personnel	.0		.0		.0		.0		.0		.0		.0	
Total Direct Personnel	2.6		10.7		12.3		10.3		9.3		7.3		5.3	
Department of Health and Human Services														
Total Operating	5.8	5.8	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Technical Personnel	53.1		59.0		59.0		59.0		59.0		59.0		59.0	
Other Direct Personnel	.4		1.0		1.0		1.0		1.0		1.0		1.0	
Total Direct Personnel	53.5		60.0		60.0		60.0		60.0		60.0		60.0	
Environmental Protection Agency														
Total Operating	4.3	4.3	4.4	4.4	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Technical Personnel	28.1		29.0		29.0		29.0		29.0		29.0		29.0	
Other Direct Personnel	.2		1.0		1.0		1.0		1.0		1.0		1.0	
Total Direct Personnel	28.3		30.0		30.0		30.0		30.0		30.0		30.0	
National Science Foundation														
Total Operating	1.8	1.8	2.2	2.2	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Capital Equipment	.0		.0		.0		.0		.0		.0		.0	
Total Program	1.8		2.3		2.5		2.5		2.5		2.5		2.5	

Technical Personnel	8.7		12.0		12.0		12.0		12.0		12.0		12.0	
Other Direct Personnel	2.7		1.3		1.5		1.5		1.5		1.5		1.5	
Total Direct Personnel	11.4		13.3		13.5		13.5		13.5		13.5		13.5	
Tennessee Valley Authority														
Total Operating	.3	.3	.6	.6	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7
Technical Personnel	2.0		5.6		4.9		4.9		4.9		4.9		4.9	
Other Direct Personnel	.0		.0		.0		.0		.0		.0		.0	
Total Direct Personnel	2.0		5.6		4.9		4.9		4.9		4.9		4.9	
Other Federal Agencies														
Total Operating	3.6	3.6	5.4	5.5	2.5	2.5	2.5	2.5	2.4	2.4	2.4	2.4	2.4	2.4
Capital Equipment	.0		.1		.1		.1		.1		.1		.1	
Total Program	3.6		5.4		2.6		2.6		2.5		2.5		2.5	
Technical Personnel	9.0		18.0		14.6		14.4		13.4		13.4		13.4	
Other Direct Personnel	1.9		3.6		2.4		2.0		2.0		2.0		2.0	
Total Direct Personnel	10.9		21.6		17.0		16.4		15.4		15.4		15.4	
Electric Power Research Institute														
Total Operating	1.9	1.9	2.9	2.7	2.7	2.7	2.2	2.2	1.3	1.5	1.3	1.3	1.3	1.3
Technical Personnel	11.5		8.8		7.7		7.7		7.7		7.7		7.7	
Other Direct Personnel	.8		1.0		1.0		1.0		1.0		1.0		1.0	
Total Direct Personnel	12.3		9.8		8.7		8.7		8.7		8.7		8.7	
Other Nonfederal Agencies														
Total Operating	4.4	4.4	4.3	4.8	3.8	3.8	3.9	3.9	2.0	2.0	2.0	2.0	2.0	2.0
Technical Personnel	18.5		20.1		18.6		18.8		14.7		14.7		14.7	
Other Direct Personnel	5.1		2.8		.5		.5		.0		.0		.0	
Total Direct Personnel	23.6		22.9		19.1		19.3		14.7		14.7		14.7	
Work for Others														
Total Operating	78.4	78.4	91.5	86.4	88.8	83.4	83.3	83.7	80.3	80.8	80.0	80.4	79.8	80.2
Capital Equipment	.8		2.2		.9		.8		.8		.8		.8	
Total Asst Secretary	79.2		93.8		89.8		84.1		81.1		80.8		80.6	

Table A.5 (continued)

	FY 1984		FY 1985[a]		FY 1986[a]		FY 1987[a]		FY 1988		FY 1989		FY 1990	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
Technical Personnel	347.9		431.3		407.2		410.2		404.1		402.1		400.1	
Other Direct Personnel	44.2		41.2		36.7		36.2		35.7		35.7		35.7	
Total Direct Personnel	392.1		472.5		443.9		446.4		439.8		437.8		435.8	
Total Program Resources														
Total Operating	363.3	358.8	370.1	379.2	421.6	406.9	424.1	418.8	430.2	424.5	429.9	430.6	434.2	434.8
Capital Equipment	21.9		24.6		20.4		33.7		40.6		51.4		33.3	
Construction	10.5		7.1		2.7		.0		.0		.0		.0	
Total Program	395.8		401.8		444.8		457.8		470.7		481.3		467.5	
Proposed Construction	.0		.0		18.8		31.9		45.2		56.7		90.0	
Env. Concerns Project	.0		16.2		35.9		99.0		153.9		93.5		.0	
Technical Personnel	1747.3		1989.1		2058.9		2098.1		2122.3		2148.3		2167.8	
Other Direct Personnel	450.6		224.1		237.8		243.1		242.8		244.8		244.8	
Total Direct Personnel	2197.9		2213.2		2296.7		2341.2		2365.1		2393.1		2412.6	

[a] Escalation factors from FY 1984 to FY 1985 and from FY 1985 to FY 1986 are both 7.0%. Figures for FY 1987 through FY 1990 are in constant FY 1986 dollars.



Oak Ridge National Laboratory organizational chart.

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