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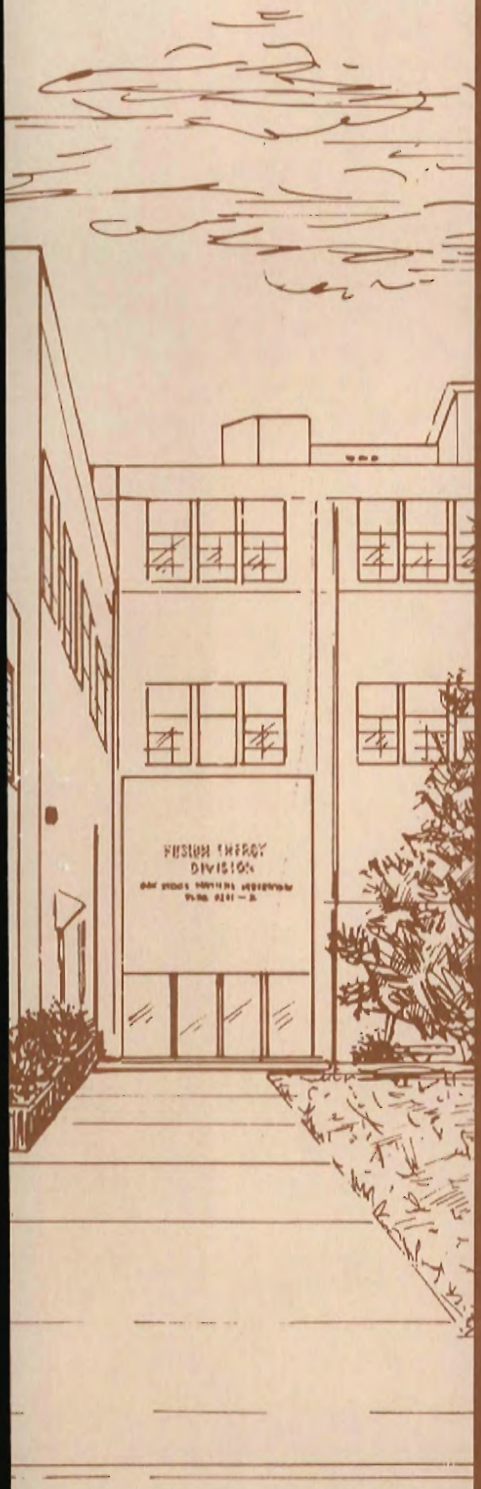
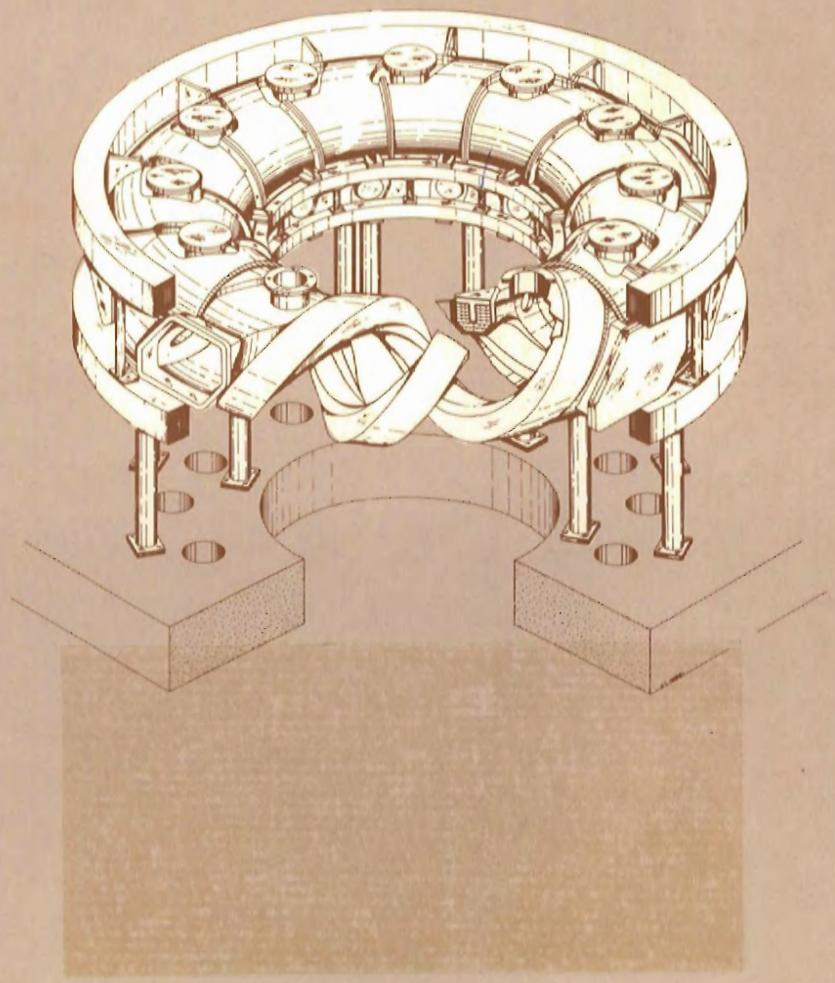


OAK RIDGE NATIONAL LABORATORY INSTITUTIONAL PLAN FY 1986—FY 1991



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Cover: *An artist's conception of the Advanced Toroidal Facility, which is currently under construction as the most recent in a series of key experiments at ORNL in the nation's Magnetic Fusion Energy Program.* Design by A. D. Richardson.

ORNL/PPA-85/2

OAK RIDGE NATIONAL LABORATORY INSTITUTIONAL PLAN FY 1986–FY 1991

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CONTENTS

Director's Statement 3

Laboratory Missions 7

Laboratory Strategic View 11

Planning Assumptions 11
General Environment 11
Laboratory Boundaries 12
Activity Trends 12
Long-Range Implications 14

Initiatives 17

New Initiatives from Last Year 17
Center for Neutron Research 17
Strategic National Defense System 17
Protein Engineering (Bioprocess) Research and Development 17

New Initiatives 18
Computing Sciences: Parallel Computing and Artificial Intelligence 18
Heavy Ion Cooling Ring 20

Overview of Laboratory Activities 23

Scientific and Technical Programs 27

Department of Energy Programs 27
Office of Energy Research 27
Assistant Secretary for Nuclear Energy 39
Office of Civilian Radioactive Waste Management 44
Assistant Secretary for Defense Programs 45
Assistant Secretary for Conservation and Renewable Energy 48
Assistant Secretary for Fossil Energy 53
Energy Information Administration 54
Assistant Secretary for Environment, Safety, and Health 54
Federal Energy Regulatory Commission 56
Assistant Secretary for International Affairs and Energy Emergencies 56
Assistant Secretary for Management and Administration 56
Office of Policy, Planning, and Analysis 57

Work for Other DOE Installations . . . 58

Work for Others . . . 59
Nuclear Regulatory Commission . . . 59
Department of Defense . . . 60
Department of the Interior . . . 66
Department of Health and Human Services . . . 67
Environmental Protection Agency . . . 67
National Science Foundation . . . 68
Tennessee Valley Authority . . . 69
Federal Emergency Management Agency . . . 69
Department of Transportation . . . 70
Department of Education . . . 70
Department of Justice . . . 71
Department of Labor . . . 71
Agency for International Development . . . 72
Other Federal Agencies . . . 72
Nonfederal Organizations . . . 73

Site and Facilities . . . 77

Site Development . . . 77

Facilities Plans: 1986–91 . . . 78

Multiprogram Energy Laboratories Revitalization Project . . . 78
General Plant Projects . . . 78
General-Purpose Equipment . . . 81

Requirements for Computing Equipment . . . 82
A Distributed Scientific and Technical Computing System . . . 83
Networks . . . 83
Research in Parallel Computing . . . 84

External Interactions . . . 87

University Programs . . . 87

Technology Transfer Program . . . 88
Overview of Existing Program . . . 88

Appendix. Resource Projections . . . 93

ACRONYMS

AACE	Athens Automation and Control Experiment
AEC	Atomic Energy Commission
AEOD	Office for Analysis and Evaluation of Operational Data
AI	artificial intelligence
AID	Agency for International Development
AIM	Accelerator Improvements and Modifications
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
ASM	advanced servomanipulator
ASNE	Assistant Secretary for Nuclear Energy
ATF	Advanced Toroidal Facility
AUB	Athens Utility Board
BA	budget authorization
BER	Building Equipment Research
BO	budget obligation
BRET	Breeder Reprocessing Engineering Test
BTESM	Building Thermal Envelope Systems and Materials
CBCF	carbon-bonded carbon fiber
CDEP	Cooperative Developmental Energy Program
CDIC	Carbon Dioxide Information Center
CESAR	Center for Engineering Systems Advanced Research
CFRP	Consolidated Fuel Reprocessing Program
CNR	Center for Neutron Research
D&T	development and technology
DHHS	Department of Health and Human Services
DIII-D	Doublet III Device
DNA	deoxyribonucleic acid
DOD	Department of Defense
DOE	Department of Energy
DOI	Department of the Interior
DOL	Department of Labor
DOT	Department of Transportation
DP	Defense Program
DSRD	Data Systems Research and Development

EBS	Elmo Bumpy Square
EBT	Elmo Bumpy Torus
ECUT	Energy Conversion and Utilization Technologies
ED	Department of Education
EDFMIS	Department of Education Financial Management Information System
EH&S	environmental, health, and safety
EIA	Energy Information Administration
EMP	electromagnetic pulse
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
ESD	Environmental Sciences Division
ETP	Emergency Technology Program
FDA	Food and Drug Administration
FEDC	Fusion Engineering Design Center
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FTE	full-time equivalent
GPE	general-purpose equipment
GPF	General-Purpose Facility
GPP	general plant project
HASRD	Health and Safety Research Division
HBCU	historically black colleges and universities
HFIR	High-Flux Isotope Reactor
HHIRF	Holifield Heavy Ion Research Facility
HMW	hazardous and mixed waste
HPRR	Health Physics Research Reactor
HTGR	high-temperature gas-cooled reactor
HVAC	high-voltage alternating current
HVDC	high-voltage direct current
IAEA	International Atomic Energy Agency
IDB	Integrated Data Base
IET	Integrated Equipment Test
IFSMTF	International Fusion Superconducting Magnet Test Facility
INS	Immigration and Naturalization Service
ISX-B	Impurity Studies Tokamak Experiment
JAERI	Japanese Atomic Energy Research Institute
JET	Joint European Torus
LAN	local area network
LLNL	Lawrence Livermore National Laboratory
LLW	low-level waste
LMR	liquid-metal reactor
LWR	light-water reactor
MEL	Multiprogram Energy Laboratories
MGPF	Multiprogram General-Purpose Facilities
MHTR	modular high-temperature reactor
NASA	National Aeronautics and Space Administration
NCI	National Cancer Institute

NEPA	National Environmental Policy Act
NLM	National Library of Medicine
NPOVS	Nuclear Power Options Viability Study
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
OSM	Office of Surface Mining
OTA	Office of Technology Assessment
PPPL	Princeton Plasma Physics Laboratory
R&D	research and development
RAP	Remedial Action Program
RCS	Residential Conservation Service
RF	radio frequency
RFTF	Radio Frequency Test Facility
RH-TRU	remote-handled transuranic
RIMS	Resonance Ionization Mass Spectrometry
SCO	Support Contractor Office
SCSS	Sequence Coding and Search System
SDI	Strategic Defense Initiative
SFC	Synthetic Fuels Corporation
SRL	Savannah River Laboratory
STX	Spherical Tokamak Experiment
TEXTOR	Tokamak Experiment for Technical Oriented Research
TFTR	Tokamak Fusion Test Reactor
TRU	transuranic
TVA	Tennessee Valley Authority
WFO	work for others

Director's Statement

DIRECTOR'S STATEMENT

A change from past practice has taken place that may well affect the future development of Oak Ridge National Laboratory (ORNL). At the request of the Department of Energy (DOE), a strategic view of the prospects and required actions through the year 2001 has been developed. Our senior management has taken this opportunity to evaluate the directions that ORNL should follow for the next 15 years.

Central to this planning activity are assumptions regarding the environment in which we will be operating. It is our conviction that, within the next 5 years, we will see another period of heightened interest in energy research and development (R&D). The directions of worldwide energy consumption and production point to liquid fuels as a central issue during this next "energy crisis." New interest in fission energy will probably develop as it becomes evident that the United States has lost its ability to shape the future of nuclear use throughout the world. Also, a large, demonstration fusion device will be built through an international effort. Current trends indicate that the national interest in processing wastes of all types will continue throughout the planning period. Even if political events result in an arms limitation agreement, this will probably have little impact on the R&D program for defensive weapons. Many important new R&D areas will develop as a result of heightened interest in computer applications and computational efficiencies.

During the planning period, the majority of work at ORNL will continue to be funded by DOE. The amount of work performed for others will grow. Energy R&D will continue as the primary responsibility of the Laboratory. Activity will increase in civilian and military areas where our energy R&D activities have given us expertise, such as nonnuclear defensive weapons development. Much effort will go into transferring technology to the scientific and industrial communities. As much as 5% of the total Laboratory effort may be applied to direct work for industry in areas requiring our unique capabilities.

The composition of the Laboratory will change during the next 15 years as the program emphasis shifts to major missions in energy and related defense technologies. Broadly stated, the goals in these areas are

1. to preserve and advance nuclear power,
2. to develop a net-power-producing magnetic fusion reactor,
3. to focus conservation and fossil energy research in areas of special competence,
4. to support the Strategic Defense Initiative in areas of special competence,
5. to create a strong technical base for basic energy sciences,
6. to create a basic understanding of the environmental and health effects of energy technologies,
7. to create and support national facilities in basic physics, and
8. to become the center for hazardous waste science and technology.

To perform the tasks associated with large projects, a critical size is required. Our analysis has determined that the Laboratory must grow to continue to perform in an exemplary fashion. We project that ORNL must be 20% to 50% larger by 2001 to meet the demands placed on us.

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 development in fusion, fission, and other energy technologies and scientific research in basic physical and life sciences to underpin work in the energy technologies. A secondary mission of the Laboratory is to use its resources to address other nationally important issues, such as hazardous and chemical wastes and non-nuclear defense technologies, when such work is closely related to the primary mission. In addition, ORNL designs and provides research facilities for the benefit of members of the scientific and technical community and supplies radioactive and stable isotopes that are not available from the private sector.

To fulfill its missions, 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 superconducting confinement magnets, and testing of candidate first-wall and blanket materials; (2) nuclear fission, with emphasis on development of nuclear fuel reprocessing, materials testing and development for high-temperature gas-cooled and advanced converter reactors, and technologies for managing nuclear and chemical waste; (3) biological and environmental basic and applied 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, with emphasis on materials, environmental control technologies, and environmental safety and health research; and (6) basic research in physical sciences, with emphasis in materials research on radiation effects, neutron scattering, and surface physics; in chemical sciences on aqueous solutions; and in nuclear physics on heavy-ion reactions. In addition, ORNL maintains close interactions with scientific and technical personnel in universities and industry.

Laboratory Strategic View

LABORATORY STRATEGIC VIEW

What will happen, what could happen, and what we want to happen are three different ways of thinking about the future. The ORNL "Strategic View" represents the convictions of the Laboratory's senior management about the future and about the role they want ORNL to play in that future. Thus, our strategic view is what we want to happen. Whether it actually happens is, of course, unknown; but knowing where we want to go is an important part of getting there. For purposes of this activity, the planning horizon extends 15 years to the year 2001.

Planning Assumptions

General Environment

Within the next 5 years, energy will once again become a very important area for research and development (R&D). Energy supplies in the United States and the world will tighten substantially in the latter part of this decade, and conditions will be right for another round of "energy crises." As before, the central issue will be liquid fuels. The production and efficient use of liquid fuels will become focal points for a revived energy R&D program. In the electrical energy area, the rest of the world will continue to accelerate the movement toward nuclear energy, and it will become evident that this nation's forfeiture of its leadership position in nuclear technology cost it dearly in terms of lost opportunities in international trade and lost influence over important matters such as direction, safety standards, and fissile material control; this realization on the part of our federal government will result in a revitalized national effort in fission power reactors. Fusion energy R&D will continue to be an important activity with a strong element of international cooperation and collaboration. Near the end of the planning period, a large superconducting advanced toroidal fusion experiment will be built in the Oak Ridge area.

The question of hazardous chemical and nuclear wastes will continue to be nationally important throughout the remainder of this century and beyond. Techniques and technologies for neutralizing existing hazardous waste sites will, for the first half of the planning period, be the highest priority objectives of the national R&D program on wastes. Efforts related to the waste problems will produce a better understanding of natural water systems and will lead to new areas of research on dilute and dispersed insults and on needs and mechanisms for improved water use and conservation.

Arms limitations agreements will be reached with the Soviet Union, and the production and deployment of nuclear weapons will decline. Nevertheless, weapons R&D will continue as a large and very important national activity. Defensive weapons will be a strong emphasis of the R&D program.

Important new R&D opportunities will develop in a number of fields, including computational areas such as artificial intelligence (AI), robotics, teleoperations, intelligent machines, and parallel computing. These areas offer the means by which the United States can once again be an international industrial leader.

Laboratory Boundaries

ORNL will remain a government-owned, contractor-operated R&D institution throughout the 15-year planning period. The federal agency responsible for ORNL will be the Department of Energy (DOE) or a successor agency. A large part of the work carried out at the Laboratory will be for the "mother agency," but a substantial amount (30% to 40%) of work for others (WFO) will be permitted. Energy R&D will continue to be the central theme of the Laboratory's work, but other closely related civilian and military R&D activities will be important. The defense R&D opportunities will be in areas other than nuclear weapons, which will continue to be handled by the "weapons labs." Other critical activities will include stewardship of basic physics research. The conception, design, construction, and operation of unique national user facilities will remain an important part of ORNL's charter. Collaboration and cooperation with researchers from academia and industry will continue to increase.

The relationship of ORNL to other components of Martin Marietta Energy Systems, Inc., will undergo evolutionary changes resulting in a much stronger capability to undertake large, complex projects. The Laboratory will become the center for advanced developmental activities for Energy Systems, and the other facilities will play the project and production roles.

Activity Trends

The major change in character of the Laboratory over the next 15 years will be a shift toward major technological missions in energy and in related defense areas. Broad goals in these areas are

- to preserve and advance nuclear power through R&D directed toward
  - — developing a new generation of economical, reliable, and safe power reactors,
  - — ensuring safe and reliable long-term operation of current light-water reactors (LWRs),
  - — removing waste storage and disposal as an impediment to the expansion of nuclear power, and
  - — diversifying into military applications of advanced nuclear systems;
- to become the developer of a net-power-producing magnetic fusion reactor, with particular emphasis on R&D support for the next major fusion experiment through
  - — developing magnets, heating concepts, fueling prototypes, and materials,
  - — leading the reactor design efforts, and
  - — conducting innovative toroidal experiments;
- to conduct advanced development work in important focused areas of non-nuclear energy technologies:
  - — fossil energy, with emphasis on materials, environment and health, environmental control technologies, and innovative research on coal chemistry as related to the production of liquid fuels, and
  - — conservation/renewables, with emphasis on materials, conservation in buildings, biomass, and electric energy systems;

- to create a strong technological base in generic areas of energy development in support of the preceding technologies by conducting basic and applied research in
  - — materials sciences (alloys, ceramics, and composites),
  - — separations sciences (chemical, biological, and mechanical processes),
  - — computational sciences (AI, parallel processing, intelligent machines, networking, and information science), and
  - — measurement sciences (controls and sensors);
- to identify and understand important environmental and health effects associated with the energy areas of emphasis:
  - — basic and applied biological research on genetic and somatic effects of radiation and chemical exposures,
  - — relationships of primary energy effluents to global environmental issues, with emphasis on terrestrial effects,
  - — dose effects relationships in man, and
  - — development of health assessments and risk analyses in these areas;
- to carry out basic research in nuclear physics, with emphasis on heavy ion and neutron physics;
- to contribute to the development of defensive weapons through major R&D activities on
  - — space power sources,
  - — energy storage,
  - — neutral particle beams, and
  - — rail guns;
- to become an important R&D center for nuclear and non-nuclear wastes:
  - — emphasis on surface storage of nuclear wastes and
  - — DOE's R&D center for hazardous chemical wastes;
- to become the center for advanced development for Energy Systems in appropriate areas including
  - — materials environment processing; and
- to actively transfer technologies and techniques to the industrial and academic communities through
  - — an aggressive industrial association, including working for industry,
  - — user facilities, and
  - — ties with selected universities and consortia.

Long-Range Implications

Changes in program areas over the next 15 years are depicted in Fig. 1. By the end of the planning period, the Laboratory will be 20% to 50% larger than it is now. The growth will be associated primarily with the technology areas, including fission, fusion, fossil, defense, and wastes. In the energy areas, even stronger international collaboration is anticipated as the projects become larger and as the United States recognizes the advanced and competitive state of foreign science and technology.

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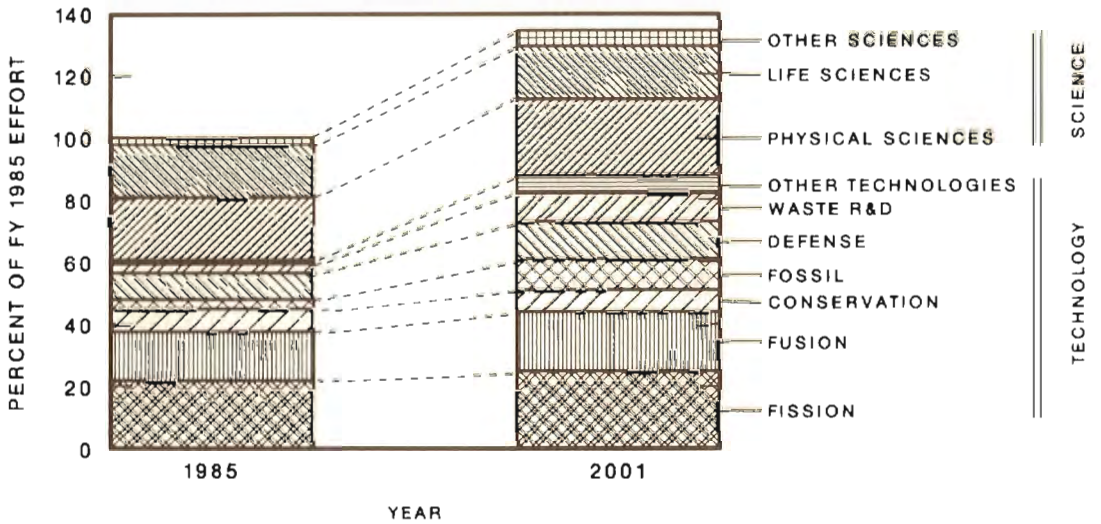

Fig. 1. Trends in internal research and development (R&D) effort—1985 to 2001.

As shown in Fig. 2, some shifts in sponsorship will take place over the next several years, reflecting participation by the Laboratory in important R&D activities outside energy—primarily in defense and in wastes. Nevertheless, DOE will remain ORNL's largest and most important sponsor.

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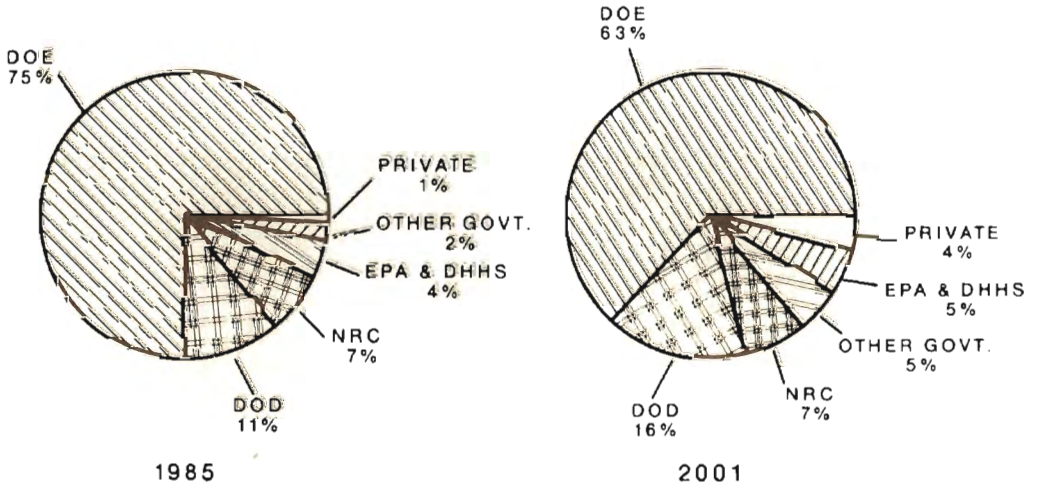


Fig. 2. Sponsors shown as percentages of internal effort.

Initiatives

INITIATIVES

The process of evaluating new, innovative projects to select New Initiatives has proven to be of significant value to ORNL. Once again we have chosen as New Initiatives projects that we believe are important for the development and direction of the Laboratory. Illustrative of the influence of this process, we think that the New Initiatives proposed last year in the *ORNL Institutional Plan FY 1985–FY 1990* hold the promise of profoundly affecting the future of ORNL. Our confidence in the importance and validity of these initiatives is demonstrated by the expenditure of the Laboratory's Exploratory Studies funds on them for preliminary investigations. We remain confident that these are important areas in which to be involved. The importance of these areas to the Laboratory and the need to continue advancing these initiatives make it imperative that we bring them to the attention of the cognizant secretarial officers once again.

New Initiatives from Last Year

Center for Neutron Research

Originally proposed as the High-Flux Isotope Reactor II (HFIR II), the Center for Neutron Research (CNR) will (1) provide unsurpassed neutron-scattering facilities for the growing community of scientists who are using the neutron as a probe to study the structure and dynamics of materials, (2) improve ORNL's isotope production capabilities, and (3) provide improved, flexible facilities for materials irradiation studies.

Strategic National Defense System

This work will use and build on technologies and experience well established at ORNL. Current planning places the Laboratory involvement in (1) neutral-particle beam source technology, (2) advanced mirror fabrication development, (3) the multi-megawatt reactor program, (4) kinetic energy weapons pulsed-power systems, (5) the neutral-particle beam continuous wave ground test facility, (6) the kinetic energy weapons ground test facility, and (7) the role of lead laboratory for energy systems development.

Protein Engineering (Bioprocess) Research and Development

Methods now exist to alter any amino acid residue of a protein by site-directed mutagenesis of its genes. We are combining our expertise in protein biochemistry and molecular genetics to continue a research initiative in protein engineering and bioprocessing. This initiative is 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 modify genes directly 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 new vistas for innovative biotechnology. However, most bioprocessing systems are still based on the technology of many years ago. A concerted effort has been 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 and in environmental control technology. We will also review the need for associated modern instrumentation that could be useful to bioprocess activities. The goal is 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 Bioprocess Research Facility User Resource.

New Initiatives

Computing Sciences: Parallel Computing and Artificial Intelligence

The continuing increase in the amount of computing power that can be purchased with a given amount of money will allow computers to be applied to more and more aspects of our work. Energy Systems realizes that the timely application of this technology will be critically important to its goal of increasing efficiency and productivity. Parallel computing (i.e., developing architecture to enable many processors to work together on a single big problem) is important because the main advances in computing hardware have made computers not so much faster as cheaper. This means that increases in computer power will depend more and more on learning how to harness processors to work in parallel on a problem. A second important area in computer applications is the area of AI. The increased power of computers is allowing them to interact with users and processes in more sophisticated ways. In many (narrow and well-defined) areas of knowledge, computer programs can now answer questions as well as and faster than the best human experts. AI is also of central importance to the problem of process and robot control, which we believe will be of critical importance in energy-related fields.

Because the bandwidth of current state-of-the-art supercomputers is only approximately one order of magnitude below the theoretical limit imposed by the speed of light, any significant improvement in computational speed will probably is likely to result from parallel processing. This proposed effort will investigate the efficient use of parallel computers for solving large-scale scientific computational problems. The research will initially focus on the development of algorithms to solve major tasks in computing the solution to partial differential equations on parallel computers. Creation of algorithms for matrix computations is an existing area of strength for ORNL and is consistent with the mission of DOE. To focus our software development efforts, we have acquired two 64-node machines—the Intel Hypercube and the NCUBE-1. We will investigate the mapping of the computational problem onto the architectures of these parallel computers to maximize the potential for increased use of the processors and

solution of the matrix equation resulting from discretization of the continuous differential equation. Both control-flow and data-flow algorithms for solving the latter task will be investigated. In addition, methods will be developed for mapping an arbitrary static process structure onto an ensemble machine for problems such as robot dynamics. Other efforts are being directed toward the development of a new parallel processor machine intended for the very-high-speed execution of expert system programs. Inherent in its architecture is fault tolerance—self-diagnosis and self-reorganization. This quality is extremely useful in applications where error-free, real-time response must be guaranteed. This machine is extremely fast; it will be able to execute expert systems at least 50 times faster than current LISP (list processing) machines.

AI, a rapidly expanding field, is expected to grow by a hundredfold within the next decade. We propose using the existing HFIR as a testbed for in-depth investigation of new AI concepts that have a potential impact on power generating plants (i.e., computer control of the power plant under normal and abnormal conditions). This effort will apply new concepts for intelligent instrumentation and control for both autonomous systems and complex systems that require human interaction. This proposed work will be beneficial to HFIR and will lead to an advanced control system for the proposed CNR.

An intelligent device will be developed that is capable of serving as a cooperative, expert advisor to the HFIR operators. The device will monitor plant status and identify incipient transients and failures using pattern recognition techniques. It will perform diagnostics and recommend corrective actions, using an expert system that has embedded human expertise, and will attempt analogous reasoning for problems with uncertain ("fuzzy") data or for situations not previously anticipated. The system will communicate with the operator in an intelligent fashion, using simple English-language commands, and respond to queries for "what-if" type of information. We shall also investigate using object-oriented programming for plant status displays and incorporating speech as part of the man-machine interface. The development of such a device involves research in the areas of knowledge engineering (i.e., capture of human expertise and its embedment in the control structure of complex systems), man-machine interfacing, and reasoning by analogy.

An important product of these efforts in the computing sciences will be a collection of researchers who are familiar with the architectures, operating systems, languages, and algorithms for supercomputers of the future. Another benefit will be the development of AI expertise capable of contributing in the many research and development disciplines necessary for meeting future energy research goals. This research will improve ORNL's ability to make future contributions to the development and application of advanced supercomputers. We welcome the opportunity for cooperative research with other energy research laboratories through avenues such as networking.

Funding requirements for Computing Sciences are shown in Table 1.

Table 1. Budget projections by fiscal year for Computing Sciences: parallel computing and artificial intelligence

($ in millions)

1986	1987	1988	1989	1990	1991
2.1	2.5	3.2	4.3	6.1	9.6

Heavy Ion Cooling Ring

A synchrotron cooling ring with stored beams of cooled, highly charged heavy ions is proposed for atomic collision studies. Current accelerator-based atomic physics research is limited by the phase space characteristics of beams of highly charged heavy ions. The proposed storage ring would provide cooled beams with very small transverse momentum spread and effective increases in current of up to 10^6 compared to existing ion sources. This would allow precision spectroscopy with crossed and merged beams of ions, electrons, photons, and atoms. Operating in the energy range of 10 keV to 25 MeV/nucleon, the heavy ion cooling ring would form an addition to heavy ion accelerators at the Holifield Heavy Ion Research Facility (HHIRF). The international atomic physics community has focused on the possibilities for research at a heavy ion cooling ring for the past 2 years, and several such rings are planned or under construction in Europe. This is the first such facility proposed in the United States.

The project will consist of a small synchrotron cooling ring of approximately 34-m circumference. A special electron gun for producing low-temperature, intense beams of electrons will be used to cool heavy ions circulating in the ring. The project will also include special equipment for injecting heavy ions from the tandem electrostatic accelerator at HHIRF and from an electron cyclotron resonance ion source. Capability will be provided for accelerating or decelerating the beams and for experiments in the ring and at external targets. The ring will be able to accommodate very heavy ions, such as uranium nuclei, with a bending limit of 1.5 tesla meters. An available option is to inject and accelerate electrons to 500 MeV so as to use the ring as a vacuum ultraviolet synchrotron light source.

Many types of atomic physics collisions studies could be carried out if stored beams of cooled, highly charged heavy ions were available. These include experiments of interest to basic research and to applied programs such as magnetic fusion. Specific topics include radiative recombination, dielectric recombination, electron-pair recombination, multi-charged ion excitation and ionization, laser-enhanced interactions, electron capture and loss processes, and atomic transitions of highly charged ions. In addition, some nuclear physics experiments, such as precision studies of giant resonances, could be performed.

Preconceptual design studies are already in progress. ORNL is a suitable site for the heavy ion cooling ring because of the availability of HHIRF and an experienced staff of atomic and accelerator physicists. The ring will be housed in the atomic physics facility being built adjacent to the HHIRF. The addition of the heavy ion cooling ring will significantly enhance the research capabilities of the new facility.

Funding requirements for the heavy ion cooling ring are shown in Table 2.

Table 2. Resource projections: Heavy Ion Cooling Ring

($ in millions)

	Fiscal year				Total estimated cost
	1988	1989	1990	1991	
Procurement and construction	1.1	2.4	2.0	0.5	6.0

Overview of Laboratory Activities

OVERVIEW OF LABORATORY ACTIVITIES

Since 1979 DOE's Office of Energy Research (OER) has been ORNL's largest single sponsor, funding roughly 41% of our total FY-1985 effort, based on total Laboratory direct personnel. The Director of OER also has overall responsibility for the Laboratory. The Assistant Secretary for Nuclear Energy (ASNE), the Assistant Secretary for Defense 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 3 shows 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. A slight shift in WFO sponsorship is expected, with the relative share of effort for the Nuclear Regulatory Commission (NRC) decreasing slightly (from 7% to 3%) over the planning period. This shift is balanced by an increase in effort for various branches of the Department of Defense (DOD), which is projected to increase from an FY 1984 level of 3% to roughly 25% in FY 1991. Figure 4 gives information on the distribution of WFO funding and personnel. Although the NRC is no longer dominant, this agency still funds 28% of ORNL WFO tasks.

ORNL-DWG 85C-15517

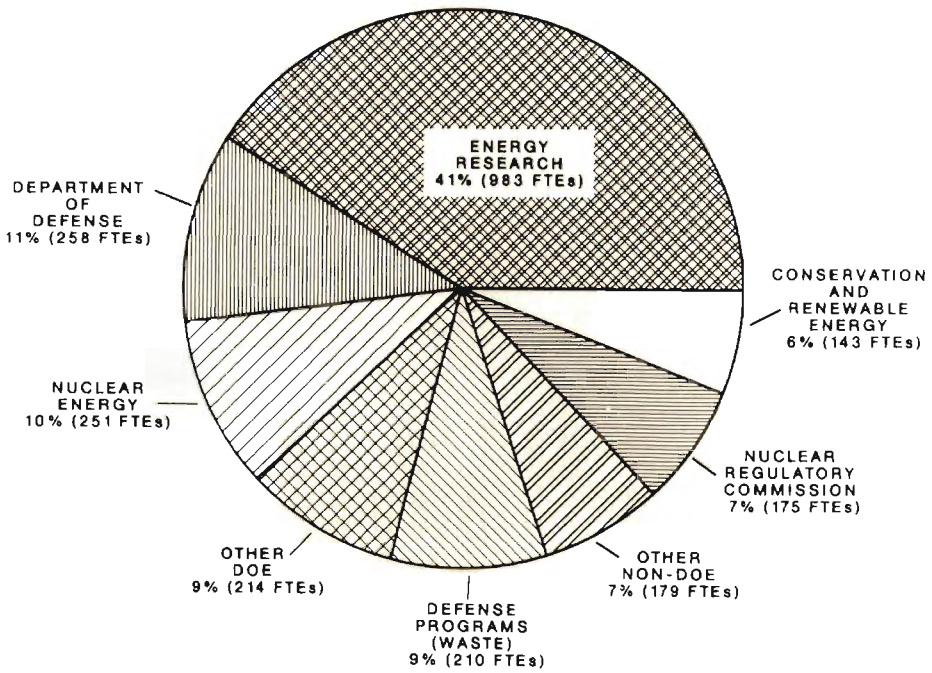


Fig. 3. FY-1985 effort for major sponsors. The total of 2413 direct full-time equivalents (FTEs) includes Computing and Telecommunications Division, Engineering Division, Y-12 Plant, and Oak Ridge Gaseous Diffusion Plant personnel who are charged to Oak Ridge National Laboratory.

ORNL-DWG 85C-15516

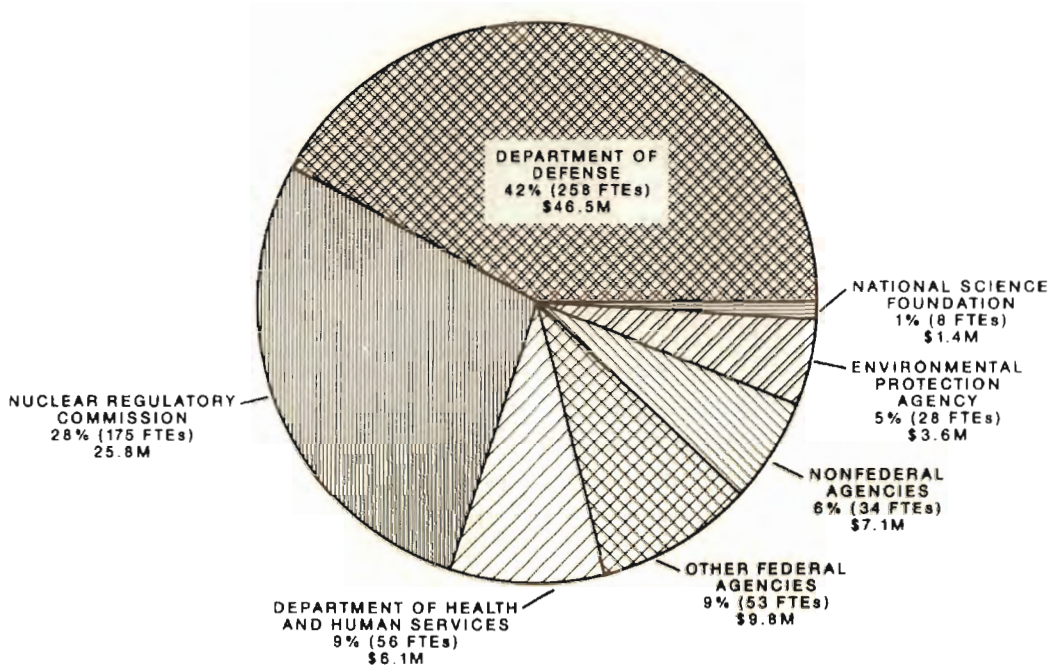


Fig. 4. FY-1985 effort in work for others. The totals of $100.3 million and 613 full-time equivalents (FTEs) include Computing and Telecommunications Division, Engineering Division, Y-12 Plant, and Oak Ridge Gaseous Diffusion Plant personnel who are charged to Oak Ridge National Laboratory.

If programmatic effort is distributed as projected in this plan, the total number of personnel projected for FY 1991 is still below the FY 1981 level. Thus, the Laboratory's overall plan is for slight growth in the near term and moderate growth in the longer term (i.e., to the year 2001).

Scientific and Technical Programs

SCIENTIFIC AND TECHNICAL PROGRAMS

Department of Energy Programs

Office of Energy Research

The Laboratory's major research programs in the basic physical sciences, fusion energy, and biomedical and environmental sciences areas are supported by OER. By supporting roughly 41% of Laboratory personnel, OER is the largest single sponsor of research at ORNL (Table 3).

Table 3. Office of Energy Research major program summary[a]

[$ in millions—budget authorization (BA)]

Budget and reporting code	Major program	Fiscal year			
		1984	1985	1986	1987
AT	Magnetic Fusion	65.66	57.86	57.47	66.35
HA02	Biomedical and Environmental Research	29.67	27.60	28.83	44.40[b]
KA	High-Energy Physics	0.61	0.59	0.51	0.54
KB	Nuclear Physics	10.92	12.96	11.97	12.17
KC	Basic Energy Sciences	52.82	70.61[c]	69.35[d]	76.10[e]
KD	Energy Research and Analysis	0.96	0.47	1.06	1.07
KE	University Research Support	0.08	0.30	0.32	0.34
KG	Environmental Compliance		5.4	22.2[f]	52.9[g]
Total		160.72	175.79	191.71	253.87
Percentage of total Laboratory funding—BA		40.6	36.6	40.4	42.4

[a]Figures include operating BA, capital equipment, and funded/budgeted construction, if any.
[b]This figure includes $13.7 million of construction.
[c]This figure includes $2.8 million of construction.
[d]This figure includes $8.2 million of construction.
[e]This figure includes $14.2 million of construction.
[f]This figure includes $3.0 million of construction.
[g]This figure includes $15.0 million of construction.

AT—Magnetic Fusion

The Fusion Program at ORNL is a major component of the 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 nuclear energy of the light elements, mainly hydrogen isotopes and lithium, can be released for useful purposes. Key issues at the current stage of the program are (1) understanding the behavior of high-temperature hydrogen isotope plasmas and development of magnetic configurations that confine plasma effectively and have attractive engineering features; (2) understanding the physics of burning plasmas; (3) development of technologies for producing, heating, and controlling such plasmas; (4) development of fusion nuclear technologies that will be required for components to operate in the fusion reactor environment; and (5) development of materials for the fusion reactor environment.

Support for contributions of the ORNL Magnetic Fusion Program comes in three areas: Applied Plasma Physics (AT05), Confinement (AT10), and Development and Technology (D&T) (AT15). The Applied Plasma Physics subprogram continues to concentrate on theoretical studies, atomic physics, and diagnostic development. The Confinement subprogram is concentrating on a switch from the Elmo Bumpy Torus (EBT) program and the Impurity Studies Tokamak Experiment (ISX-B) to the Advanced Toroidal Facility (ATF) program, which begins operation in FY 1987. Simultaneously, proposals are being prepared for the Elmo Bumpy Square (EBS) device, to continue the EBT research, and for the Spherical Tokamak Experiment (STX), a modestly priced, low-aspect-ratio tokamak. Major emphasis in the D&T program is to operate the International Fusion Superconducting Magnet Test Facility (IFSMTF, formerly known as the Large-Coil Test Facility) in FY 1986 with all six coils and to use the new Radio Frequency Test Facility (RFTF) as a key facility in a vigorous radio frequency (RF) technology development program. Work also continues on plasma theory, advance design activities, pellet fueling, materials, and neutronics. The ORNL program is now involved in and plans to continue major collaborative programs, in essentially all of its activities, with the major U.S. fusion laboratories and with many foreign countries.

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 reversed field pinch). This activity also encompasses the development of a database and of models 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, heat and particle transport, and heating and fueling. Studies of critical issues will be made for ATF, EBS, and STX. Studies of advanced systems such as ATF-2, the burning-plasma experiment, and reactors will continue. In the atomic physics program, a powerful new source of multiply-charged ions is operating, which considerably expands the range of highly ionized systems available for investigations. 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, the development of a diagnostic device for measuring fusion alpha particles will continue.

Confinement systems activities have traditionally included experiments and design studies in the EBT and toroidal plasma configurations. During the last 2 years, studies of the EBT scale 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. In response to this information, the imaginative EBS configuration with significantly

improved plasma confinement capabilities has been proposed as the new focus of this program. The EBS uses hot electron rings in bumpy straight sections combined with high-field corners, which minimize the effects of toroidal curvature on drift orbits. The Magnetic Fusion Advisory Committee reviewed the EBS (along with other alternative concepts) and found it to be an exciting concept justifying further support. Work continues on updating the EBS proposal, and it will be resubmitted for FY-1986 funding.

The toroidal area has three major program elements. ORNL researchers, primarily those on off-site assignment to Princeton Plasma Physics Laboratory (PPPL), play an important role in the Tokamak Fusion Test Reactor (TFTR) program at PPPL. This collaboration peaked in FY 1985 but continues through FY 1986. The second activity is design and construction of the ATF stellarator; the facility modifications required for its physics operation are proceeding on schedule. This facility will be available for the experimental program to start in early FY 1987, and it is planned to operate into the early 1990s. A device with outstanding capabilities, ATF has the flexibility to study various magnetic configurations and, with a suitable upgrade, to operate with a high-performance steady-state plasma. ATF will provide a major in-house focus for theory and experimentation, diagnostics, and plasma technology. The third element is the definition of physics and engineering issues associated with a tokamak operating at very low aspect ratio, the Spherical Torus concept. A proposal to construct a specific embodiment of this concept (STX) was submitted late in FY 1985. This device promises higher plasma beta than conventional tokamaks, and the concept offers potential advantages as a reactor.

The D&T program continues to make progress on all fronts. An RFTF, based on the prototype EBT proof-of-principle coils, was built and will be used for testing advanced RF development components. Development of RF systems and components is proceeding, with initial applications planned for the Doublet III Device (DIII-D), ATF, and Tore Supra experiments. Components developed from this work will also be used on the Tokamak Experiment for Technical Oriented Research (TEXTOR), the Tandem Mirror Experiment, and others. The pellet injector program is working on advanced pellet injectors that can repetitively provide pellets at speeds of up to 2 km/s. These injectors are being used to fuel the TFTR, DIII-D, Princeton Large Torus, Princeton Beta Experiment, and Alcator-C experiments in the United States. A system is being designed for Tore Supra (France), and systems are being considered for the Joint European Torus (JET) (England) and JT-60 (Japan).

In the Large-Coil Program, the IFSMTF is being readied for the six-coil torus tests that are the goal of the international project. Since completion of tests with the first three coils in 1984, the remaining three coils have been completed: one built by Siemens for KfK/EURATOM, one started by General Electric and finished by the Oak Ridge Gaseous Diffusion Plant (ORGDP), and one built by Westinghouse. Testing will begin early in FY 1986 and continue into FY 1987.

The plasma materials interactions program is focused on limiter development, wall conditioning/impurity control, scrape-off layer diagnostics, and surface physics. Until start-up of the ATF in FY 1987, the activity will concentrate on collaborative programs on Heliotron-E, TEXTOR, and Tore Supra. In the radiation materials area, work continues in the HFIR and the Oak Ridge Research Reactor to test candidate first-wall and blanket materials. A multi-year collaborative program with the Japanese Atomic Energy Research Institute (JAERI) is under way. The program will continue to pursue three primary goals: (1) to provide materials behavior information in support of reactor design studies, (2) to select structural materials and develop a database for near-term fusion devices, and (3) to develop low-activation alloys for commercial fusion reactors. Programs involving ceramics and copper are in the planning state.

The Fusion Engineering Design Center (FEDC), which is managed by ORNL, collaborates extensively with a number of U.S. industries, national laboratories, and universities. The FEDC is a major contributor to conceptual design of the ignition devices that are candidates for the next major focus of the U.S. Magnetic Fusion Program. The FEDC also plays a leading role in physics and engineering studies for the U.S. contribution to the International Atomic Energy Agency (IAEA)/International Tokamak Reactor activity. In addition, in collaboration with Lawrence Livermore National Laboratory (LLNL), a significant effort is devoted to the design of future tandem mirror devices. These studies are expected to expand in the near future to include other confinement concepts.

In the ignition device program, the Fusion Energy Division is also providing leadership in coordinating plasma physics activities. Through this work, the FEDC effort, and support to other technology 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 are concerned that this trend has not leveled out. Beginning in FY 1984, the HA02 (Environmental R&D) and HB (Life Sciences Research and Nuclear Medicine Applications) programs were consolidated under the single activity code HA02 (Biological and Environmental Research).

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, and chemical interactions and effects. This research is conducted mainly in the Biology Division. Environmental science research covers ecology, environmental toxicology, hydrology, environmental risk analysis, biogeochemistry, geology, carbon dioxide (CO_2), and acidic deposition. Health and safety research encompasses epidemiology, health assessments, 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 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 and industry and students and staff from universities.

The ORNL HA02 program is one of 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 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 investigating hypotheses about the inhibition or enhancement of adverse health 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 research efforts in protein engineering, as described in more detail in the "New Initiatives" section. Additional work is anticipated by several ORNL divisions through the ORNL Biotechnology Program.

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, 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 200,000 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 are associated with the conversion of healthy cells to cancer cells. Research on damage to organ systems includes the quantitative interactions of energy-related substances with genetic materials.

Biophysics research in the Biology Division will concentrate 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, paying particular attention to cell membranes and their function in health and in disease.

Environmental research is designed to increase our understanding of the transport and effects of energy-related contaminants in the environment. Basic information is developed on mechanisms that govern ecosystem function, particularly in biogeochemical cycling studies on forested landscapes (Walker Branch Watershed) and in southeastern reservoirs. This forms the basis for research on the ecological response to chemical emissions stressing both aquatic and terrestrial environments. By using 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 our work in hydrology and geochemistry in support of DOE programs in subsurface transport of hazardous substances. New research will address regional landscape patterns and the processes affecting ecosystems at large spatial scales. In the area of global environmental concerns, ORNL has become a center of expertise in the investigation of ecological transport and effects of chemicals in the environment and in the assessment of hazardous wastes, the CO_2 elements, and acid deposition issues. Research on vegetation response to air pollution stress, particularly O_3, SO_x, NO_x and acid deposition,

has received national prominence. 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. Environmental Sciences Division (ESD) research for OHER focuses on biogeochemical cycling at the watershed scale with Walker Branch Watershed as a central focus but includes atmospheric deposition inputs, biogeochemical cycling, subsurface hydrologic transport, and element cycles and effects in streams and river/reservoir ecosystems. 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 response to encouragement from DOE, ORNL staff members have collaborated with Argonne National Laboratory (ANL), Brookhaven National Laboratory, and Pacific Northwest Laboratory to prepare a major proposal 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 to (1) demonstrate the extent and rates of integrated watershed responses, given certain ecosystems characteristics and differing levels of atmospheric deposition of acidity, and (2) 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 5 years, 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. New work is being initiated on the direct and indirect effects of CO_2 on the physiological responses of both above- and below-ground vegetation, including mycorrhizal associations. ORNL anticipates recognition as a major research center during the new, international Geosphere Biosphere Program being planned by the International Council of Scientific Unions.

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 its 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 requires 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 improving 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 OHER. HASRD also conducts work for other federal agencies as it relates to DOE-OER-OHER interests. Although 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 current and future needs for assessing exposures of people to various insults; and development of assessment methodologies that allow quantitative judgments to be made on current and future impact of various energy strategies, energy production levels, and possible energy-related mishaps.

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, and gases, on solid surfaces, and at 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 to 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 microlithograpy.

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. Research has been recently initiated to determine which biological screening systems may be more predictive of human level health effects. This research is directly supportive of new health effects assessment methods.

The HPRR, a unique research facility, 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 is available to continue these studies. New funding has also been developed to implement a battery of in vitro testing systems for complex mixtures of water-borne toxic materials.

Some changes have occurred in the proposed line item construction projects for the HA02 program (Table 4). The largest item, which is proposed for 1987, was renamed from Toxic Substances Laboratory and Animal Facility to Mammalian Genetics Research Facility to be more accurately descriptive of projected functional use. DOE/OHER's established genetics research program investigates the genetic effects of energy-related chemicals. For this purpose, it is essential that we have new laboratory and animal space designed specifically to enable personnel to handle hazardous chemicals safely. The revised total estimated cost reflects minor rescoping, resiting, and revision of cost escalation factors.

Table 4. HAO2—Construction summary

($ in millions)

	Fiscal year							Total estimated cost
	1985	1986	1987	1988	1989	1990	1991	
Proposed construction								
Health and Safety Research Laboratory			3.5					3.5
Upgrade air supply system, Building 9210, part I			2.4					2.4
Mammalian Genetics Research Facility[a]			7.8	11.5	4.7			24.0[b]
Upgrade air supply system, Building 9210, part II				3.4				3.4

[a]Formerly known as the Toxic Substances Laboratory and Animal Facility. The name was changed to describe more accurately the use of the facility.

[b]Costs for this project have been reduced as the result of a recent scope change and cost estimate.

The air supply system upgrade is essential for achieving a higher number of air exchanges per hour in the experimental animal quarters in the Biology Division, thus preserving a unique resource among DOE contractors. The scope of the project was revised to reflect accomplishment of some work in an FY-1986 general plant project (GPP) task. The Health and Safety Research Laboratory will support our ongoing work in occupational health research and related areas.

KA—High-Energy Physics

The High-Energy Physics program provides calculated nuclear cross sections and transport data for the design of experiments, instrumentation, and shielding at high-energy accelerators. Nuclear cross section models and nuclear-meson transport methods are developed and applied to specific problems in particle detection and radiation shielding for the high-energy physics community. The program supplies both calculated data and computer codes to high-energy facility designers and experimenters and qualifies and improves the data and models by comparison with experimental results and incorporation of advances in nuclear theory and computational methods. These activities are projected to continue throughout the planning period.

ORNL collaboration with The University of Tennessee in experimental high-energy physics will continue at the current level of one person-year annually.

KB—Nuclear Physics

The Nuclear Physics program operates the HHIRF as a national user facility and for the in-house heavy ion research program. A modest increase in nuclear physics support is projected over the planning period to provide enhanced use of HHIRF and to strengthen related efforts in heavy ion theory. Increased use of HHIRF by DOD and the National Aeronautics and Space Administration (NASA) is anticipated for single-event upset experiments in semiconductors. Continued involvement in relativistic heavy ion experiments at the Conseil Europeen pour la Recherche Nucleaire is planned and will include substantial development of instrumentation at ORNL. A major new area is the proposed construction of a heavy ion booster and storage ring at HHIRF. The new facility would use the existing 25-MV tandem accelerator as an injector and would provide high-duty-factor heavy ion beams with energies up to 500 MeV/nucleon and previously unattainable energy spreads (10^{-4}), enabling frontier experiments in nuclear resonance behavior and quantum electrodynamics.

Program Construction. An Accelerator Improvements and Modifications project for the HHIRF and a Heavy Ion Synchrotron and Storage Ring are proposed (Table 5).

Table 5. KB—Construction summary

($ in millions)

	Fiscal year							Total estimated cost
	1985	1986	1987	1988	1989	1990	1991	
Budgeted construction								
Accelerator Improvements and Modifications		0.5						0.5
Holifield Heavy Ion Research Facility 25-MV Tandem, Extended Tube Upgrade								
Proposed construction								
Heavy Ion Booster Synchrotron and Storage Ring					12.0	15.0	12.0	39.0

KC—Basic Energy Sciences

This program includes work in nuclear sciences, materials sciences, chemical sciences, engineering and geosciences, biological energy research, and applied mathematical sciences.

The Nuclear Sciences (KC01) subprogram supports operation of the High-Flux Isotope Reactor/Transuranic (HFIR/TRU) facility for transplutonium isotope production, the Oak Ridge Electron Accelerator (ORELA) for nuclear data measurements, and the calutrons for electromagnetic separation of isotopes. HFIR/TRU and the calutrons are unique sources of special isotopes for research, medicine, and other applications. A significant increase in the use of ^{252}Cf from the HFIR/TRU facility for structural inspection of military aircraft is projected for the planning period. Overall operating levels for Nuclear Sciences will remain approximately the same through FY 1991, with continued budgetary stringencies at the calutrons and HFIR/TRU and some construction involving minor modifications to HFIR and ORELA.

In the Materials Sciences (KC02), growth is projected in surface science and neutron scattering. Emphasis on user facilities will be increased with expansion of the Surface Modification and Characterization Facility and completion of the National Low-Temperature Neutron Irradiation Facility. R&D activities associated with high-temperature alloys, toughened ceramics, and new composite materials will continue to grow. Research in polymer structures will be expanded. Collaboration with the steel industry on fabrication and control technologies will grow and foster increased industry-laboratory interaction in the materials sciences.

A major laboratory initiative involving both the nuclear and materials sciences will be the design and beginning construction of the CNR, the world's best research reactor for neutron-scattering studies, transplutonium isotope production, and radiation damage studies. The new reactor would incorporate an advanced core design with the latest in beam tube technology to achieve a minimum factor-of-10 increase in neutron flux available for scattering experiments compared to existing sources. Operated as a national user facility, CNR would help the country regain leadership in important areas of condensed matter physics, structural biology, and materials science. This leadership was recently lost to the European Institut Laue-Langevin facility in Grenoble. CNR could be operational in the mid-1990s to replace HFIR, which was constructed in 1965.

In the Chemical Sciences (KC03), an internal review of the role of the Laboratory in separations science is under way and will lead to new proposals in this important area. A Heavy Ion Cooling Ring is being proposed for the new Holifield Applications and Atomic Physics Laboratory for precision measurements of ion-electron, ion-atom, and ion-photon collision phenomena. This facility is one of the Laboratory's new initiatives for FY 1986 (see the "New Initiatives" section of this report for additional details). The proposed Analytical Mass Spectrometry Laboratory (AMSL) would relocate advanced analytical equipment now at Y-12 to the X-10 site, improving access to this equipment for Chemical Sciences programs and outside users. Increased activity in waste immobilization and environmental control technologies is projected. ORNL participation in the Large Einsteinium Activation Project will increase.

The Engineering and Geosciences (KC04) program will emphasize R&D on intelligent machines and participation in DOE-sponsored continental drilling experiments. Significant growth is projected for the Center for Engineering Systems Advanced Research (CESAR), including completion of new laboratory space in FY 1986. Activities at CESAR will include research in autonomous robotics, including sensor-based navigation, machine vision, and learning from experience.

Substantial growth is projected in Biological Energy Research (KC06) to exploit neutron scattering to characterize biologically driven conversion systems (such as membranes) important in energy technologies. Applied Mathematical Sciences (KC07) will also grow with continued emphasis on the development of algorithms for parallel computing (see "New Initiatives" for additional details). Laboratory-wide efforts in the theory of nonlinear phenomena will be coordinated to strengthen this important field at ORNL.

Program Construction. A number of Accelerator and Reactor Improvement and Modification projects are proposed. In addition, funding for the AMSL, a Solid State Sciences Research Laboratory, the CNR, and a Heavy Ion Cooling Ring are proposed (Table 6). Details of the Heavy Ion Cooling Ring proposal may be found in "New Initiatives."

Table 6. KC—Construction summary

($ in millions)

	Fiscal year							Total estimated cost
	1985	1986	1987	1988	1989	1990	1991	
Funded construction								
Accelerator and Reactor Improvements and Modifications (ARIM)								
High-Flux Isotope Reactor (HFIR) heat exchanger	0.3							0.3
Budgeted construction								
ARIM								
HFIR heat exchanger and Remote Sampling Facility		0.8	0.4					1.2
Proposed construction								
Center for Neutron Research[a]		2.0	6.0	10.0	14.0	40.0	60.0	312.0[b]
ARIM								
Holifield Heavy Ion Research Facility Beam Lines			0.3					0.3
HFIR Critical Facility			0.3					0.3
Oak Ridge Electron Linear Accelerator			0.6					0.6
Analytical Mass Spectrometry Laboratory			0.7	4.2				4.9
Solid State Sciences Research Facility[c]					4.0	5.0		9.0
Heavy Ion Cooling Ring				6.0				6.0

[a]Formerly called HFIR-II.
[b]Amount includes funding that extends beyond 1991.
[c]Formerly called Surface Sciences Research Facility.

KD—Energy Research and Analysis

ORNL supports the OER in technical and economic assessments of energy-related technologies and in technical assessments of DOE programs. Short-term evaluations are carried out by ORNL staff and subcontractors in response to specific requests by OER. Activities are projected to continue at their current level of effort.

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 1985 under the auspices of the program, and significant growth is projected for the future. Several new programs were developed and implemented in FY 1985: (1) summer field experience for area high school math and science teachers, (2) a computational sciences workshop for Tennessee high school honors students, and (3) assignment of industrial researchers to ORNL. Development of the new activities in secondary education and industrial participation is expected to increase. Program development is also under way for historically black colleges and universities (HBCUs), which have received a significant amount of programmatic funding. The KE support will be used primarily to investigate and develop new opportunities.

KG—Environmental Compliance

The Environmental Restoration and Facilities Upgrade Program is a large new program supported by Program KG, Environmental Compliance. It was initiated in FY 1985 in response to a compliance inspection by the Environmental Protection Agency (EPA) and the State of Tennessee, which emphasized the need to reduce hazardous chemical and radionuclide discharges to the environment and to accelerate environmental compliance activities on a comprehensive basis. This program will conduct remedial actions at process ponds, at spill sites, and at locations in the White Oak Creek watershed where past practices have contaminated facilities or the environment to levels that require corrective measures. This effort will involve substantial amounts of site characterization work, assessment of alternatives for National Environmental Policy Act (NEPA) compliance, and assessment of post-stabilization performance as well as actual remedial actions. The program will also coordinate projects to improve or develop systems for collection, treatment, storage, and disposal of radioactive and hazardous chemical wastes and to improve environmental monitoring capabilities for the site. Another important function of the program is to develop a plan for decommissioning ORNL facilities that are not eligible for inclusion in DOE's Surplus Facilities Management Program because of their relation to active technical programs.

Funding for the program is expected to increase rapidly in FY 1986 and 1987 (Table 7) as site characterization efforts are completed and remedial action projects begin. A preliminary list of projects is given in ORNL/TM-9200, *Environmental Management at ORNL, Five-Year Project Plan (FY 1985-1989).* Additional definition and development of the scope and criteria for projects are continuing.

Table 7. KG—Construction summary

($ in millions)

	Fiscal year							Total estimated cost
	1985	1986	1987	1988	1989	1990	1991	
Proposed construction Environmental compliance		3.0	15.0		40.0			58.0

Assistant Secretary for Nuclear Energy

The ASNE is the major sponsor of applied nuclear research. Programs funded through this office are multidisciplinary in nature and include, as major activities, advanced nuclear systems for space and terrestrial applications; civilian reactor programs including liquid-metal reactor (LMR), gas-cooled reactor, and LWR systems; remedial action programs; nuclear waste management; and nuclear fuel recycle (Table 8).

Table 8. Assistant Secretary for Nuclear Energy major program summary[a]

[$ in millions—budget authorization (BA)]

Budget and reporting code	Major program	Fiscal year			
		1984	1985	1986	1987
AE	Advanced Nuclear Systems	2.28	2.16	3.88	5.48
AF	Breeder Reactor Systems	10.08	10.21	7.40	6.40
AG	Convertor Reactor Systems	5.40	4.65	3.94	6.46
AH	Remedial Action Programs	2.93	6.60	8.78	8.79
AP	Commercial Nuclear Waste Management	0.46	0.27	0.03	0.03
AS	Nuclear Fuel Cycle	27.81[b]	18.16[b]	13.10	15.00
CD	Uranium Enrichment	0.33	0.74	0.50	0.50
Total		49.29	42.79	37.63	42.66
Percentage of total Laboratory funding—BA		12.5	8.9	7.9	7.2

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

AE—Advanced Nuclear Systems

Improved materials for space missions and terrestrial applications that use heat generated by isotopic power devices are being developed and evaluated. Activities include 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) nondestructive-examination support for manufacture of advanced thermoelectric elements and the iridium alloy blanks, and (4) evaluation of measurements of the diffusivity and steady-state thermal conductivity of CBCF insulating material.

ORNL will continue in its lead role in the development and characterization of refractory alloys in the Strategic Defense Initiative (SDI) program on fission reactor concepts for power levels in the hundreds of kilowatts (SP-100 Program) as well as for the multimegawatt concepts described elsewhere in this document. In the Ground Engineering System phase of the

SP-100 Program, beginning in FY 1986, it is anticipated that ORNL will also have a substantial role in the technology areas of reactor shielding, measurement and control, and structural design methods.

AF/AG—Civilian Reactor Program Overview

The goal of the U.S. Civilian Reactor Program is to ensure the nation's energy future through the establishment of attractive and commercially viable nuclear energy options and the necessary technology base. The program is being restructured to more broadly address advanced converter reactor systems based on water, gas, and sodium coolants. Although the sodium-cooled breeder reactor is recognized as a vital long-term need to provide an essentially inexhaustible energy supply, current predictions of uranium use reduce the pressure for early breeder development. The LMR concept, however, continues to show promise as an advanced converter. ORNL will continue to support DOE's concept development and base technology programs and offer its broad expertise in fission reactor technology for the restructured program.

In keeping with this policy, ORNL has proposed a new initiative in Advanced Reactor Technology with major activities including (1) Availability Improvement Technology, (2) Advanced Control and Information Handling, (3) Advanced Technology for Design of Improved Evolutionary LWRs, and (4) Advanced Construction Technology. The goal is to provide improved enabling technologies in support of the entire U.S. Civilian Reactor Program. We anticipate an initial startup in FY 1986 focused on Advanced Control and Information Handling.

AF—Breeder Reactor Systems

This program continues to support the LMR concept, with principal efforts in the base-technology areas of measurement and control, shielding, materials, structures, and safety. Emphasis is on tasks in support of (1) innovative, low-cost, and passively safe designs and (2) important international collaborative efforts.

Measurement and control activities will focus on man-machine integration, on automated control methods employing AI, and, to a lesser extent, on high-temperature fission counters and systems for automated surveillance and diagnostics.

In the shielding task, experiments at the Tower Shielding Facility will be performed in a collaborative effort with the Japanese to investigate alternative shielding materials such as B_4C for LMR near-core and deep-sodium environments. In addition, analytical and experimental support will be provided for advanced LMR designs.

In materials and structures, we will continue to develop and code-qualify the modified 9Cr-1Mo steel, provide improved design methods and criteria, and develop advanced in-service inspection techniques.

The safety work will be concentrated in a joint program of the United States and Japan to develop a centralized advanced reactor reliability data base and operate a reliability data analysis center.

The Performance Assurance Project Office will continue to promote the development of consensus industrial standards and special program standards, as required, and to ensure that the information and experience gained in all nuclear programs are made available to the private sector. Program support for DOE's unusual-occurrence-report activities will be continued.

AG—Converter Reactor Systems

This program includes the new Advanced Reactor Technology initiative, the LWR program, the high-temperature gas-cooled reactor (HTGR) program, and analysis and support activities such as the Nuclear Power Options Viability Study (NPOVS).

An expanded LWR technology development effort is anticipated in DOE. Improved LWR technology is an urgent national need to support improvements in performance and availability of current-generation LWRs as well as advanced concepts. Close cooperation with the Electric Power Research Institute (EPRI), the utility industry, and the nuclear power industry will be essential in planning and implementing this effort. A national LWR upgrade program is envisioned by ORNL with coordination and technology development by DOE, technology transfer and demonstration by EPRI, and technology confirmation and implementation by the utility industry. We expect to play a prominent role in DOE's expanded LWR program because of our broad expertise in LWR technology. Continuing LWR tasks include annual updating of the energy economic data base and engineering economic comparisons of nuclear options vs other energy sources.

Primary emphasis in the national HTGR program will be on development of a modular high-temperature reactor (MHTR), using steel pressure vessels for the reactor core and steam generators in a side-by-side arrangement. The use of steel vessels facilitates factory fabrication and shipping to the reactor site. Pebble-bed fuel or prismatic-type fuel elements are being considered. Pebble-bed fuel allows on-line refueling, while prismatic-type fuel permits easy replacement of reflector elements and possible use of annular-type cores operating at high power levels [350 MW(t) vs 250 MW(t)]. The passive safety features of MHTR units show promise of permitting physical demonstration of a number of design basis events; such a successful demonstration could greatly simplify safety-related regulatory issues. MHTR cost savings are anticipated because of the potential for high-quality automated factory fabrication, streamlined licensing, standardized construction, non-safety-grade balance-of-plant construction, use of incremental financing, and reduced rate-base impact. The program target will be a full-scale demonstration MHTR in operation by 1994. Based on this goal, funding for the HTGR program is expected to increase.

The primary mission of ORNL in this activity is to provide technological expertise in support of the national HTGR program to develop passively safe, economically attractive HTGRs for electricity production, cogeneration, and high-temperature process heat. ORNL has the lead responsibility for the Base Technology Development Program. Technical activities include (1) performing qualification tests of HTGR fuel performance and fission product behavior under postulated 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 gas/magnetic-bearing circulators, which pump coolant around the reactor circuit; (4) providing analytical and experimental evaluation of shielding designs; (5) evaluating the reactivity worth of control rods and the reactivity coefficients associated with items such as water ingress and temperature changes; and (6) providing technical and economic evaluations and assessments.

The NPOVS has developed criteria to evaluate the viability of nuclear options, conducted preliminary evaluation of selected concepts, and assessed key issues including public risk, investment risks, economic competitiveness, licensability, probability of cost/schedule overruns, and technical readiness. Follow-on studies may be conducted at a modest level of effort.

AH—Remedial Action Programs

Major activities in Remedial Action Programs (RAPs) involve management of surplus facilities and the conduct of radiological surveys on private properties near inactive mill tailings sites and at facilities formerly used under contract with the Atomic Energy Commission (AEC). Identification, evaluation, and documentation of the current 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 RAP maintains an office staffed by the HASRD in Grand Junction, Colorado, to perform its activities in a cost-effective manner. The national importance of this program is manifested by the FY 1985 funding level of $4.5 million, an increase of more than $3 million over FY 1984. Advancing state-of-the-art equipment and methodologies is an integral part of this work. Radiological survey efforts will increase substantially in FY 1986 and FY 1987 to more than $7 million to support work by the remedial action contractors. Survey efforts will be reduced sharply in FY 1988 when nearly all inclusion surveys will be completed. The survey program is expected to stabilize at a level of more than $1 million to fund certification surveys and other work as needed. The surplus facilities effort is expected to increase substantially in FY 1990 when engineering assessments of surplus experimental nuclear reactors are initiated. The small task for geophysical studies to support remedial actions at former AEC sites was completed in FY 1985.

AP—Commercial Nuclear Waste Management

The Commercial Nuclear Waste Management program provides minor support for the Integrated Data Base (IDB) and funds two tasks on low-level waste (LLW) technology development. These tasks include the conduct of a licensing demonstration for a mock site and a field demonstration of geophysical diffraction tomography to provide quantitative information on subsurface geophysical properties. These tasks were completed in FY 1985, but token support for the IDB is expected to continue.

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 10 years, ORNL has been developing the technology for reprocessing spent fuel; the major emphasis has been on the special problems of breeder fuels. In this time, experienced ORNL 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 variety of activities that must be carried out in hazardous environments: fusion, waste disposal, decommissioning, and cleanup of reactors and other nuclear facilities.

The major emphasis over the past 3 years has been on completing fabrication and installation of hardware for the 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), was also initiated in FY 1983. However, in FY 1985 DOE deferred the BRET project until the overall breeder strategy is redefined. The ORNL CFRP is continuing component and operational testing and evaluation in the Remote Operation and Maintenance Demonstration and the Integrated Process Demonstration portions of the IET facility.

ORNL is leading a major collaborative strategy study, initiated in FY 1985, with Hanford Engineering Development Laboratory to examine overall options and strategies for the fast reactor fuel cycle and to support innovative reactor design studies that DOE also initiated in FY 1985. The Secure Automated Fabrication facility and the proposed BRET facility located in the Fuels and Materials Examination Facility complex at Hanford, with expansion of their current capabilities, have been investigated as one option for an initial fuel cycle. The other option is for a small fuel cycle located at the reactor station.

ORNL will continue its active role in efforts to foster international collaboration and to examine the merits of future cooperative fuel cycle projects. Other countries are maintaining 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 exhange continue. France and the Federal of Republic of Germany have expressed interest in exchanges with the United States in this field, and details of the exchange agreements are being developed with both countries. Exhange agreements with Japan are in place and work is in progress for collaboration in experimental criticality work and in application of remote technology. Japan's Power Reactor and Nuclear Fuel Development Corporation is providing major funding for the criticality program. In addition, the possibility of broader collaboration is being discussed. Efforts to develop international cooperation will continue to increase benefits and to reduce research costs for the United States and the other participants.

As major development work on the advanced servomanipulator (ASM) is concluded (with full operation of the prototype model), efforts to transfer this technology to industry are being pursued. Industry interest in seeking a market and commercializing the technology will be sought by requesting cost sharing and fees for an exclusive licensing arrangement to the successful industrial bidder. Follow-on activities in further development of the ASM will be substantially influenced by the outcome of this technology transfer effort.

In addition, an effort is under way to form a multi-organization group to develop a mobile rescue vehicle for use by DOE in hazardous or emergency situations (e.g., reactor accidents, spills, etc.). The CFRP is proposed as a leading participant, the organizer, and catalyst. To succeed, this effort requires the cooperation of several government laboratories. The role of potential industrial partners would have to be worked out.

The use of centrifugal contactors for solvent extraction process applications offers the advantages of rapid startup, short solution residence time, compact size, high mass transfer efficiency, and potentially lower overall system cost when compared with more conventional contactors. Additional improvements in performance and reliability are possible with some additional development. Furthermore, the potential for simplification of the overall solvent extraction system will be explored. For example, highly efficient and compact centrifugal contactors may allow systems that have fewer purification cycles. The discrete stage characteristics of such systems also provide the possibility for including interstage electrochemical operations for valence control. Plans are being explored to use existing laboratory facilities at Savannah River Laboratory (SRL) to perform U-Pu separation tests. Contactor applications in the nuclear industry include both commercial and defense fuel reprocessing, scrap recovery operations for fuel fabrication and weapons production, and waste processing. Testing and demonstration of these techniques with small-scale contactor banks will be done using major instrument and support systems within the IET.

The CFRP's 9-kW remote laser cutting system can be applied to the development of remote cutting, welding, and special heat treating procedures that have wide applications. The demonstrated ability to remotely control and automatically drive the high-power laser focus

head can be shown to have potential use in large industrial applications requiring a high-power laser.

Program Issues. The United States continues to search for a breeder or LMR program strategy. Until that is determined, the CFRP mission remains uncertain. Any LMR 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 that has been under development for the past 10 years 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.

The potential impact and/or constraints of U.S. policy regarding sensitive nuclear technology must be clarified if an overall collaboration with the free world in the fuel cycle is to be developed. Otherwise, the full breadth of the technology exchange and the benefits to the United States will not be realized.

CD—Uranium Enrichment

This activity is to support the Energy Information Administration (EIA) in an examination of the economic viability of the U.S. uranium milling and mining industry. The EIA must submit to the Secretary of DOE an annual report, which states the size of the world uranium market and U.S. production as a fraction of the total. Additionally, the report must identify and quantify the imports of power reactor fuel into the country and the impact of these imports on U.S. industry. Specific tasks include (1) collecting and analyzing data pertinent to the study, (2) determining the use and development of the international uranium supply, and (3) building demand models that forecast international uranium market conditions.

Office of Civilian Radioactive Waste Management

ORNL's work for the Office of Civilian Radioactive Waste Management (OCRWM) is conducted under Program DB, which is funded by revenues from a 1.0 mill/kWh(e) tax on electricity generated by nuclear reactors. ORNL activities in Program DB support three major components of OCRWM: first repository, second repository, and program management and technical support (Table 9).

DB—Nuclear Waste Fund

The first repository component of the Nuclear Waste Fund Program supports continuation of the sensitivity and uncertainty analysis task for the Office of Nuclear Waste Isolation (salt repositories). This task is developing a computer-based methodology to analyze uncertainty in the results of complex computer codes.

The second repository component of the program supports the investigation of sedimentary rocks other than salt as hosts for a nuclear waste repository. During FY 1984-85, the ORNL Sedimentary Rock Program conducted literature-based geotechnical investigations leading to the recommendation of the most promising of a list of sedimentary rocks (shale, sandstone, limestone, anhydrock, and chalk) for further consideration as the host medium for a high-level waste repository. A decision by OCRWM to accept and act on this recommendation would initiate a site-screening process leading to the nomination of a site in the most promising rock and subsequent in situ characterization of the site.

Table 9. Office of Civilian Radioactive Waste Management major program summary[a]

[$ in millions—budget authorization (BA)]

Budget and reporting code	Major program	Fiscal year			
		1984	1985	1986	1987
DB	Nuclear Waste Fund	1.83	3.58	4.43	4.17
DC	Civilian Radioactive Waste	0.00[b]	0.04	0.00[c]	0.00[c]
Total		1.83	3.62	4.43	4.17
Percentage of total Laboratory funding—BA		0.5	0.8	0.9	0.7

[a]Figures include operating BA and capital equipment, if any.
[b]Program was initiated in FY 1985.
[c]No additional funding is anticipated after FY 1985.

The program management and technical support component of the Nuclear Waste Fund Program has three distinct tasks: nuclear waste transportation, IDB, and environmental technical assistance. The transportation task addresses the movement of commercial wastes from the point of generation to intermediate destinations, and ultimately to the repository. These analyses support the first repository, the second repository, and the Monitored Retrievable Storage facility in OCRWM. The IDB task comprises a centralized, computerized database of inventories, projections, and characteristics of all domestic nuclear waste and spent fuels. This program is jointly funded by programs AR, AP, AG, and AH. The environmental technical assistance task provides technical support to the DOE Office of Environmental Compliance in reviewing and evaluating environmental and technical analyses prepared for the OCRWM.

Beyond these established tasks under the Nuclear Waste Fund, ORNL is pursuing greatly expanded activities in the area of transportation and in waste systems studies for the OCRWM. Potential transportation areas include providing additional transportation studies and evaluations, technical support concerning institutional aspects of the transportation system, and technical management of DOE's program to procure a modern fleet of nuclear waste transportation casks. Attractive activities relevant to the waste systems studies include performing system studies concerning reference and alternative system configurations, developing baseline information concerning system interfaces and data, coordinating system criteria development, managing technical aspects common to many portions of OCRWM, and managing the development of ideas representing cost-effective improvements to the high-level waste management system.

Assistant Secretary for Defense Programs

The major effort for the ASDP is in defense waste management and may be divided into four main categories: (1) management of wastes generated at ORNL, (2) development of technology for managing LLW and TRU radioactive wastes, (3) management of the hazardous Chemical Defense Waste Management Program for DOE, and (4) 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 10).

Table 10. Assistant Secretary for Defense Programs major program summary[a]

[$ in millions—budget authorization (BA)]

Budget and reporting code	Major program	Fiscal year			
		1984	1985	1986	1987
AR	Defense Waste Management	22.59	24.11	28.24	33.10
GC	Verification and Control Technology	0.18	0.29	0.62	0.74
GD	Safeguards and Security	0.00	0.48	0.45	0.45
GE	Materials Production	7.45	8.73	8.95	6.67
Total		30.22	33.61	38.26	40.96
Percentage of total Laboratory funding—BA		7.6	7.1	8.4	7.5

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

AR—Defense Waste and By-Products Management

Major activities under this program are the operations involved in managing radioactive and hazardous chemical wastes generated at ORNL, the development of procedures, equipment, and facilities to improve the safety and reliability of disposal operations, the decommissioning of surplus facilities, and participation in the several technology development programs supported by Defense Programs (DPs). A large effort associated with waste management operations is being directed toward assessment of all disposal options and development of new disposal facilities; the definition, completion, and assessment of the performance of corrective actions on problem areas; and the implementation of measures to comply with new regulations and orders. Substantial effort also involves defining and developing criteria and design concepts for projects that will improve or replace waste management systems that are inadequate, obsolete, or faulty. New work demonstrating the efficacy of waste management and remedial actions for the Y-12 and ORNL watersheds has been initiated using techniques developed under the OER Complex Mixtures Program.

Participation in the TRU Waste Technology Program emphasizes the development and construction of equipment and facilities for a pilot plant to demonstrate the processing and repackaging of remotely handled TRU waste for shipment to the Waste Isolation Pilot Plant. Participation in the Hazardous Chemical Defense Waste and Low-Level Waste Management Programs consists primarily of assistance to DOE in managing the programs. Major support for the IDB is also provided under this program, and increasing support is provided for tasks that are designed to foster long-term interactions of HBCUs with the defense waste management programs.

The Hazardous Waste Program Support Contractor Office (SCO) supports the Hazardous Waste Program at Oak Ridge Operations (ORO) in the technology aspects of hazardous and mixed waste (HMW) management at all DOE DP facilities. The SCO assists DP facilities with the technologies required for sound management of HMW, including generation, transportation, treatment, storage, and disposal of wastes, and environmental restoration. The SCO performs its functions through identification and evaluation of DP facilities waste management problems

and issues, support of technology development and transfer of technologies to handle waste management problems, development of waste management strategies, and assisting headquarters staff in HMW policy development. The SCO developed and maintains the Waste Information Network, a computer-based communications system that allows DP contractors, Operations Offices, headquarters, and the SCO to exchange information quickly and efficiently. The SCO performs ongoing analyses of both proposed and new legislation and regulations affecting DP waste mangement and distributes manuals, analyses, and regulatory alerts to the DP waste management community. The SCO will continue to support ORO and DOE Headquarters as waste management needs become better defined and the means for dealing with HMW evolve. The hazardous waste program budget is anticipated to increase by approximately 50% in FY 1986 and again in FY 1987.

The total program budget is expected to increase more than 10% in FY 1986 and again in FY 1987 (Table 11) and will decline thereafter as some development tasks are completed.

Table 11. AR—Construction summary
($ in millions)

	Fiscal year							Total estimated cost
	1985	1986	1987	1988	1989	1990	1991	
Budgeted construction								
Central Waste Disposal Facility		1.0		6.5				7.5
Proposed construction								
Replace liquid low-level waste system				20.0	35.0	25.0		80.0
Facility Modification for remote-handled transuranic (RH-TRU) volume reduction				3.0				3.0
RH-TRU Waste Handling Facility				5.0	30.0			35.0
General Plant Projects	2.4	2.7	3.7	3.0	3.2	3.2	3.2	21.4

GC—Verification and Control Technology

Resonance Ionization Mass Spectrometry (RIMS) for the Ultra-Trace Analysis task will exploit a recently developed technique of using 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.

GD—Safeguards and Security

This activity, begun in 1985, includes the detection of high explosives by tandem mass spectroscopic techniques and independent inventory verification and tank calibrations. The work will continue at a constant level through FY 1987.

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 materials from scrap generated by experimental studies is also recovered. Because of the decreasing interest in ^{233}U, we have agreed to place 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. Installation and checkout of equipment was completed in FY 1985 and operation was begun. The project is expected to be completed in FY 1987.

The Californium Industrial Sales/Loan Program will be transferred from SRL 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 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

ORNL activities for the ASCE encompass 11 program categories covering a diversity of conservation and renewable energy topics. The programs are devoting increased emphasis to technology transfer and coordination with industrial research. Substantial increases in budget are planned for FY 1986 in ceramic technology for advanced heat engines (EE) and Energy Conversion and Utilization Technologies (ECUT) materials (EG). These increases reflect both DOE program planning and ORNL assessments of research opportunities (Table 12). A decrease in the budget for Electric Energy Systems is expected, reflecting the lower DOE request to Congress for FY-1986 funds in this category.

AK—Electric Energy Systems Programs

Activities in the AK program deal with power systems technology through investigation of new concepts and development of future technology for the electric utility industry. Project technologies offer opportunities to improve 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 (HVAC), high-voltage direct current (HVDC), materials, electromagnetic pulse (EMP), and electric fields. Significant accomplishments during FY 1985 include determination of the properties of solid polymer insulators, continued development of fine-grained zinc oxide varistors, installation of automatic control devices and computers at the Athens (Tennessee) Utilities Board (AUB) electric distribution system, and development of a methodology to determine the effects of EMP on electric power systems.

In the future, tasks related to HVDC, dielectrics, EMP, distribution automation, and power systems information management will be emphasized; work in HVAC current will be deemphasized. A major project for the next few years will be the Athens Automation and Control

Table 12. Assistant Secretary for Conservation and Renewable Energy major program summary[a]

[$ in millions—budget authorization (BA)]

Budget and reporting code	Major program	Fiscal year			
		1984	1985	1986	1987
AK	Electric Energy Systems	5.00	7.84	4.15	6.49
AL	Energy Storage Systems	1.69	1.08	1.00	1.62
AM	Geothermal	0.00[b]	0.05	0.06	0.06
CC	Geothermal Resources Development Fund	0.11	0.06	0.08	0.08
CE	Hydropower	0.05	0.05	0.15	0.16
EB	Solar Energy	6.00	4.48	6.06	6.58
EC	Building and Community Services	11.93	12.44	13.90	13.14
ED	Industrial	1.49	1.52	1.75	1.83
EE	Transportation	15.43	15.95	15.39	18.41
EF	State and Local Programs	0.45	0.31	0.30	0.23
EG	Multisector	2.53	5.66	8.43	13.36
Total		44.68	49.44	51.27	61.96
Percentage of total Laboratory funding—BA		11.3	10.1	10.7	10.5

[a]Figures include operating BA, capital equipment, and funded/budgeted construction, if any.
[b]Major portions of FY-1984 costs were supported by prior funding obligations.

Experiment (AACE), a large-scale distribution automation and control project being installed on the AUB 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.

The addition of AI and expert systems to electric power transmission and distribution systems is an area that will receive additional study.

Another major project will be experimental verification of the methodology developed for evaluating the effect of EMP on utility systems. This experimental verification will involve installation of high-voltage electrical test equipment, which can simulate the wave shape of the EMP.

AL—Energy Storage Systems

ORNL has been assigned responsibility for field management of Thermal Energy Storage materials, systems, and use technology in the areas of building heating and cooling, industrial processes, and passive and active solar. 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 database 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 development of the sodium-sulfur battery. The outlook is for continuation of the program at approximately the current level.

AM—Geothermal

ORNL's work in geothermal research consists of assisting DOE in the preparation of required NEPA documents by examining proposed installations to ensure that the associated environmental impacts are within acceptable limits. This work is expected to remain at less than one full-time equivalent (FTE).

CC—Geothermal Resources Development Fund

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 ORNL's 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 ORNL receiving support from the DOE Idaho Operations Office.

EB—Solar Energy

The principal activity in solar energy is technical management of the Biomass Production Program, which consists of long-term research on the production of woody and herbaceous biomass, program planning, and environmental and economic research and assessment. ORNL will assist the Biomass Energy Technology Division with the following specific tasks: (1) development and administration of research on woody plants subjected to intensive culturing for high productivity; (2) development and administration of research on herbaceous crop resources; (3) complementary research on environmental effects, physiology and nutrient utilization, and economics of energy crops; and (4) interactions with the international Energy Agency Biomass Working Group member nations. An increase in funding is anticipated during the next several years as field research is implemented on the herbaceous biomass task.

ORNL participation in other solar programs is limited to tasks in which specific expertise is available, including development of simulation techniques for passive solar thermal storage (EB21); technical assistance on photovoltaic projects (EB22); environmental, health, and safety assessments on alcohol fuels projects (EB24); and analysis of wind energy systems (EB25). The latter three programs are expected to be completed in FY 1985, while passive solar thermal storage work is expected to continue throughout the planning cycle.

EC—Building and Community Systems

ORNL has been assigned technical management responsibility for four programs in the buildings area: Building Thermal Envelope Systems and Materials (BTESM), Building Energy Retrofit Research, Building Equipment Research (BER), and Residential Conservation Service (RCS). The BTESM program (EC01) 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 and subsequently updated by a panel of industry experts, forms the basis for selection of research projects. Also, joint work between DOE and the National Association of Home Builders was begun. Highlights of the FY-1985 program will be the procurement of equipment to enable thorough testing of roofing segments and expansion of materials research to include wood and masonry building products. The level of effort is expected to increase during the planning period, with increased emphasis on roofing systems, analysis of integrated building envelope systems, and expansion of technology transfer activities.

In Building Energy Retrofit Research (EC01) (previously a part of the RCS Program), ORNL has been assigned technical leadership for single-family and commercial buildings. A multi-year plan has been completed for each sector with ongoing activities to include sector characterization, analysis and monitoring of retrofit performance, improvement of retrofit selection and diagnostic tools, and development of retrofit implementation and technology transfer mechanisms.

The BER program (EC05) 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 heat pumps, 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 (EC07), which includes the extension to commercial and apartment buildings, provides DOE with technical support for rule-making activities, technical assistance for implementation of rules, and evaluation of selected state and utility programs. DOE management of RCS is expected to be transferred to State and Local Programs in FY 1985; continuation beyond FY 1986 is contingent on Congressional action and authorization of a proposed Buildings Efficiency Applications Program Plan.

Smaller, continuing roles have also been assigned to ORNL in technology transfer (EC02 and EC06) and community systems (EC03).

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.

An evaluation of industrial heat pump technology will be published in the first quarter of FY 1986. Current major program activities include screening and testing of high-temperature working fluids, computer modeling of liquid/vapor heat pump cycles, and a critical review of solid/vapor absorption systems.

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 with the possibility of additional funding in the separations area. Legislation is pending in Congress to establish a cost-shared initiative with the steel industry. The objective is to develop technologies that will allow major gains in productivity and that "leap-frog" existing technologies. If this program is enacted, ORNL expects to be a major participant.

EE—Transportation

Assignments for the Office of Vehicle and Engine Research and Development include development of ceramic technology for advanced automotive heat engines, 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 increase substantially during the next two 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, the DOD, and industry.

A new facility, the High-Temperature Materials Laboratory, is scheduled for completion and occupancy in FY 1987 (Table 13). This facility will house laboratories and unique special equipment for high-temperature materials research by ORNL staff and researchers from industry, universities, and other government laboratories.

Table 13. EE—Funded construction summary

($ in millions)

	Fiscal year							Total estimated cost
	1985	1986	1987	1988	1989	1990	1991	
High-Temperature Materials Laboratory	16.6[a]	2.7						19.3

[a]Includes funding for previous years.

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—Multi-Sector

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, light-weight 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 2 years as a result of the large number of successful developments by ORNL and several subcontractors. A new project was initiated in FY 1985 on Biocatalysis Research, also a part of ECUT; this project may grow over the next few years.

Three additional projects within EG are development of microemulsion fuels, evaluation of the Energy-Related Inventions Program, and evaluation of the National Appropriate Technology Assistance Service. These projects are expected to continue through the planning period.

Assistant Secretary for Fossil Energy

ORNL programs for the Assistant Secretary for Fossil Energy (ASFE) cover three major areas: coal, gas, and alternate fuels. The Coal Program (AA) is, however, the primary focus of the Laboratory's fossil energy activities (Table 14). The coal budget is anticipated to remain approximately constant, with primary emphasis on materials and environmental, health, and safety (EH&S) research.

Table 14. Assistant Secretary for Fossil Energy major program summary[a]

[$ in millions—budget authorization (BA)]

Budget and reporting code	Major program	Fiscal year			
		1984	1985	1986	1987
AA	Coal	9.52	7.13	8.35	7.75
AB[b]	Gas	0.00	0.00	0.00	0.00
CH[c]	Alternate Fuels Production	0.19	0.00	*d*	*d*
Total		9.71	7.13	8.35	7.75
Percentage of total Laboratory funding—BA		2.5	1.5	1.8	1.2

[a]Figures include operating BA and capital equipment, if any.

[b]Major portions of costs during the budget period are supported by prior funding obligations.

[c]Major portions of FY 1984 and 1985 costs were supported by previous-year funding obligations.

[d]Activities will cease at the end of FY 1985.

AA—Coal

The principal emphasis of ORNL's Fossil Energy Program is on materials R&D and on EH&S research. The materials R&D includes management (with DOE/ORO) of the advanced research and technology development Fossil Energy Materials Program and the Surface Gasification Materials Program and is directed toward the development of corrosion-resistant alloys

and coatings with emphasis on understanding the development and breakdown of protective oxide scales; erosion and wear-resistant alloys and cermets; high-temperature structural alloys ranging from advanced austenitic steels to ordered intermetallic alloys; and structural ceramics and refractories with emphasis on the development of whisker- or fiber-reinforced ceramic composites with improved strength and toughness. The EH&S R&D includes work directed toward characterization and control of bioactivity 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. ORNL provides broad-based technical support to the ASFE to assist in meeting DOE obligations to the Synthetic Fuels Corporation (SFC) as mandated by the Energy Security Act. This support includes multidisciplinary reviews of environmental monitoring plans prepared by potential synfuels projects under consideration by the SFC. ORNL also reviews actual project data from environmental monitoring plans and maintains a related EH&S information system for the ASFE.

Work is also carried out in a broad range of individual projects, which include work on computer modeling and simulation, particularly in the development of oil, gas, and coal supply models; evaluation of coal conversion technologies including bioconversion concepts; development of automated methods for analysis of coal liquids; and innovative research on coal chemistry as related to the production of liquid fuels.

AB—Gas

Funding in the Gas Program covers economic and technical evaluations of processes. Work in this area will be concluded in FY 1986, and future funding is not expected.

CH—Alternate Fuels Production

Work in the Alternate Fuels Production Program, covering modeling of coal gasification process technologies, will be concluded in FY 1986. Further funding in this area is not currently anticipated.

Energy Information Administration

ORNL provides research and management support to EIA. ORNL programs in support of EIA draw upon multidisciplinary teams from inside and outside the Laboratory. The work consists of data analysis, assessment, and evaluation; model development; economic evaluations; and application of statistical sampling techniques to target respondent universes. These tasks are in support of the four principal offices within EIA. During FY 1985, the funding level increased modestly over the level of recent years (Table 15). A major segment of the EIA program continues to be analysis of the viability of the U.S. uranium milling and mining industry.

Assistant Secretary for Environment, Safety, and Health

Most ORNL work for the new Assistant Secretary for Environment, Safety, and Health includes 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 16).

Table 15. Energy Information Administration major program summary[a]

[$ in millions—budget authorization (BA)]

Budget and reporting code	Major program	Fiscal year			
		1984	1985	1986	1987
TA	Collection, Production, and Analysis	1.05	2.08	1.01	1.00
TB	Program Services	0.19	0.24	*b*	*b*
Total		1.24	2.32	1.01	1.00
Percentage of total Laboratory funding—BA		0.1	0.4	0.2	0.2

[a]Figures include operating BA and capital equipment, if any.
[b]Activities will cease after FY 1985.

Table 16. Assistant Secretary for Environment, Safety, and Health major program summary[a]

[$ in millions—budget authorization (BA)]

Budget and reporting code	Major program	Fiscal year			
		1984	1985	1986	1987
HA01	Overview and Assessment	1.89	2.41	2.88	3.15
Percentage of total Laboratory funding—BA		0.5	0.5	0.6	0.5

[a]Figures include operating BA and capital equipment, 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 slightly in FY 1986. ORNL will continue NEPA support and develop a system for tracking and analyzing DOE federal regulatory initiatives. Increased effort in technical assistance to OEC for hazardous wastes will be provided. For 8 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 and the Clean Water Act Review. 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.

Federal Energy Regulatory Commission

ORNL efforts for the Federal Energy Regulatory Commission (FERC) have increased over the past year. In addition to the Susitna hydroelectric project environmental impact statement, which was 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 17).

Table 17. Federal Energy Regulatory Commission major program summary[a]

[$ in millions—budget authorization (BA)]

Budget and reporting code	Major program	Fiscal year			
		1984	1985	1986	1987
VP	Other expenses	0.52	0.79	0.75	0.75
Percentage of total Laboratory funding—BA		0.1	0.2	0.2	0.1

[a]Figures include operating BA and capital equipment, if any.

Assistant Secretary for International Affairs and Energy Emergencies

For the Assistant Secretary for International Affairs and Energy Emergencies, ORNL is 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 from FY 1984 through FY 1987 is from previously obligated budgets (Table 18).

Assistant Secretary for Management and Administration

ORNL does a small amount of work for the Assistant Secretary for Management and Administration under two budget and reporting codes, LA and WB. The LA category covers activity related to the DOE Office of Scientific and Technical 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, which is scheduled for phaseout after FY 1985. No new budget authority is requested for the WB program itself (Table 19). The Energy Conservation GPP, which is associated with WB, will continue throughout the planning cycle. These funds are listed in Table 38.

Table 18. Assistant Secretary for International Affairs and Energy Emergencies major program summary[a]

[$ in millions—budget authorization (BA)]

Budget and reporting code	Major program	Fiscal year			
		1984	1985	1986	1987
UB[b]	Utility Programs and Regulatory Intervention	0.00	0.00	0.00	*c*
UE[d]	Fuels Regulation	0.00	0.00	*e*	*e*
Percentage of total Laboratory funding—BA		0.0	0.0	0.0	0.0

[a]Figures include operating BA and capital equipment, if any.

[b]Major portions of FY 1984, 1985, and 1986 costs are supported by prior funding obligations.

[c]Activities will cease after FY 1986.

[d]Major portions of FY 1984 and 1985 costs are supported by prior funding obligations.

[e]Activities will cease after FY 1985.

Table 19. Assistant Secretary for Management and Administration major program summary[a]

[$ in millions—budget authorization (BA)]

Budget and reporting code	Major program	Fiscal year			
		1984	1985	1986	1987
LA	Technical Information Services	1.10	1.21	1.29	1.36
WB	In-House Energy Management	0.13	0.10	*b*	*b*
Total		1.23	1.31	1.29	1.36
Percentage of total Laboratory funding—BA		0.3	0.3	0.3	0.2

[a]Figures include operating BA and capital equipment, if any.

[b]Activities will cease after FY 1985.

Office of Policy, Planning, and Analysis

Work for the Office of Policy, Planning, and Analysis is now at a very modest level, and only small increases are anticipated (Table 20). It involves mostly demand-side analysis with emphasis on new technologies and the impact their penetration may have on economic efficiency and energy consumption. Supply-side studies for this office involve uncertainties associated with the supply of gaseous and liquid energy products and with the development of innovative technologies for energy production.

Table 20. Office of Policy, Planning, and Analysis major program summary[a]

[$ in millions—budget authorization (BA)]

Budget and reporting code	Major program	Fiscal year			
		1984	1985	1986	1987
PE	Policy Analysis and System Studies	*b*	0.24	0.10	0.20
Percentage of total Laboratory funding—BA			0.1	<0.1	<0.1

[a]Figures include operating BA and capital equipment, if any.
[b]Activities for this office did not begin until FY 1985.

Work for Other DOE Installations

In the Fossil Energy Program, work funded by other DOE contractors and by Energy Technology Centers includes support to the U.S. Agency for International Development (AID) (through the Pittsburgh Energy Technology Center) on fluidized-bed combustion technology, environmental and health assessment studies on direct liquefaction technology, assessment of wastewater treatment requirements for various coal gasification processes, health risk assessment, and technical support and an environmental analysis for the Strategic Petroleum Reserve (Table 21).

Table 21. Other Department of Energy contractors and Operations Offices major program summary[a]

[$ in millions—budget authorization (BA)]

Program area	Fiscal year			
	1984	1985	1986	1987
Fission	9.76	9.21	6.85	5.41
Biomedical and Environmental	0.67	2.40	2.40	2.00
Basic Physical Sciences	1.41	0.92	0.29	0.30
Fusion	0.03	0.47	0.01	0.01
Fossil	0.91	0.27	0.20	0.14
Conservation and Renewable Energy	1.18	0.21	0.20	0.35
Other	0.17	0.22	0.01	0.01
Total	14.13	13.70	9.96	8.22
Percentage of total Laboratory funding—BA	3.8	2.8	2.1	1.4

[a]Figures include operating BA and capital equipment, if any.

Work for Others

Nuclear Regulatory Commission

Of ORNL's FY 1985 operating and capital equipment budget authorization, about 6% comes from NRC, which amounts to over 25% of all the Laboratory's WFO.

Through its various programs at ORNL, NRC receives research and technical support in areas in which the Laboratory has demonstrated significant expertise, except in the area of environmental research. These areas include structural analysis, materials evaluation, fission product behavior, accident sequence analysis, advanced instrumentation and diagnostics, reliability and operating data analysis, integrated risk assessment, and radiation dose and health effects. Based on current NRC budget projections, ORNL efforts are expected to remain essentially constant after FY 1986 (Table 22).

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

Table 22. Nuclear Regulatory Commission program resource summary[a]

[$ in millions—budget authorization (BA)]

Major program office	Fiscal year			
	1984	1985	1986	1987
Nuclear Reactor Regulation	2.26	2.10	1.50	1.50
Administration	0.44	0.70	0.54	0.56
Nuclear Materials Safety and Safeguards	2.25	1.87	1.70	1.65
Nuclear Regulatory Research	22.93	22.35	17.66	16.64
Analysis and Evaluation of Operational Data	1.97	1.97	1.92	1.96
Other offices	1.49	1.02	0.75	0.56
Total	31.34	30.01	24.07	22.87
Percentage of total Laboratory funding—BA	7.9	6.2	5.0	3.9

[a]Figures include operating BA and capital equipment.

Nuclear Reactor Regulation

For the Office of Nuclear Reactor Regulation, ORNL provides technical consultation and specialized measurements for test methods to detect anomalous behavior in LWRs.

Administration

The Laboratory furnishes technical support for the Office of Administration 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 1991.

Nuclear Materials Safety and Safeguards

Efforts in behalf of the Office of Nuclear Materials Safety and Safeguards include shipping-cask analyses, environmental assessments of fuel cycle facilities, technical support and laboratory-oriented evaluation in geochemical areas related to the licensing of radioactive waste repositories, and surveys of metabolic data appropriate to high-level waste dosimetry. Continued 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 database for the behavior of fission products and aerosols in severe reactor core damage 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 core damage accidents. With the issuance of this policy statement, some decrease in fission product research is likely. In contrast, interest in extending the operational life of existing power plants beyond their original design is increasing. This trend is expected to result in increased research in aging characteristics of plant components.

Overall, a decrease in ORNL effort is anticipated beyond FY 1986, and changes in research emphasis are expected.

Analysis and Evaluation of Operational Data

Over two-thirds of the funds from the Office for Analysis and Evaluation of Operational Data (AEOD) supports 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 operation and maintenance of a nonreactor data file and a foreign reactor events file (proprietary). In addition, AEOD has also established a construction deficiency report system that is expected to be a major database for use by NRC. Funding is expected to remain stable through FY 1987.

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.

Department of Defense

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. The DOD joint agency and joint program emphasis will evolve during the planning period primarily because DOD has recognized the need and economic benefit for R&D cross-cutting programs among branch agencies. ORNL support to the Defense Advanced Research Projects Agency in machine intelligence, basic materials, and physics research is one example. Advanced computing and simulation

methods research for the office of the Joint Chiefs of Staff is another. Finally, research on standards and methods for logistics, business systems, and systems modernization techniques and prototypes for joint programs such as The Defense Standard Ammunition System and the Defense Security Assistance Agency represents another type of DOD-wide effort for which ORNL's unique research skills are important.

Work for DOD is projected to continue to represent an important fraction of the Laboratory's total budget in this planning cycle (Table 23). With the establishment of the Data Systems Research and Development (DSRD) program by Energy Systems, we expect to stabilize the ORNL growth of the past two years. 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 DOD needs. Examples include power systems, materials, structures,

Table 23. Department of Defense program resource summary[a]

[$ in millions—budget authorization (BA)]

Major program office	Fiscal year			
	1984	1985	1986	1987
Army	4.97[b]	10.07	17.18	22.90
Navy	15.15[b]	4.04	4.14	4.24
Air Force	1.63[b]	4.58	17.77	27.82
Defense Nuclear and others	0.53[b]	1.80	1.80	2.10
Strategic Defense Initiative Organization	c	0.12	8.37	29.23
Subtotal	22.28[b]	20.61	49.26	86.29
Data Systems Research and Development (DSRD)				
Army	d	9.50[e]	5.05	5.05
Navy	d	52.10[e]	18.45	20.45
Air Force	d	12.50[e]	3.55	5.05
Defense Nuclear and others	d	0.25[e]	0.63	1.76
Subtotal	d	74.35[e]	27.68	32.31
Total	22.28	94.96	76.94	118.60
Percentage of total Laboratory funding—BA	5.6	19.7	16.1	20.0

[a]Figures include operating BA and capital equipment.

[b]DSRD work is included in these figures.

[c]Work for this organization began in FY 1985.

[d]DSRD work for FY 1984 is included in the above figures.

[e]Beginning in FY 1986, management and contract support for the DSRD program are to be performed outside ORNL.

heat transfer, laser research, data analysis, DSRD (see below), interaction of radiation with microelectronic circuitry, special metals and composite materials, spectroscopic methods research, romote and machine sensing, AI, radiation measurement, instrumentation and engineering, toxic materials effects, energy conservation, and environmental and biological audits and studies.

Data Systems Research and Development

The core research function of Energy Systems' DSRD program represents an important area of work at ORNL. Although DSRD work is funded by a number of federal authorities, it is currently supported primarily by DOE and DOD. The DSRD program at ORNL is expected to grow and expand. Beginning in FY 1986, direction, management, and contracting support for DSRD is to be performed outside ORNL. ORNL research will support DSRD, and that work is directly referenced in other sections of this Institutional Plan.

DSRD involves the use of state-of-the-art data system capabilities by large public organizations to improve the effectiveness of their decision making and their efficiency in operation. Our research is targeted to information and organization theory development for very large organizations that have highly distributed data resources (and requirements), complex management structures, and needs for integration of data and information systems. We seek assignments that allow us to conduct the research necessary to improve on existing techniques and to gain familiarity with associated technologies so we can develop, understand, and use new methods. As a result, we can assist in decision making in cases where sufficient structure exists for analytic aids to be of value but where judgment is still essential.

The DSRD program emphasis is enhanced through development of the capability to provide technical expertise required for the design, prototyping, and development of all hardware/software components with the complete, integrated architectures of actual, mission-oriented, and user-specific decision-support computer data systems.

Establishment of a center of excellence for scientific research on data systems and evaluation methods useful for application to energy, environment, defense, and other important national problems is a key element of this initiative at Energy Systems and ORNL. Research includes work on expert systems; decision theory; the organizational implications of data systems; quantitative methods related to modeling, error detection, and data collection and analysis; evaluation of existing data systems and models and formulating their specifications in a broad range of problem areas; application of advanced data system methods to governmental problems, particularly management information and strategic and nontactical problems and simulations; prototyping of related computing, network, and security systems; computing research to advance the technology of data systems; research on database management techniques; and data and information flow analysis and architecture studies.

We are embarking on more fundamental research focused on methodology development for data collection and data analysis, determining how data systems are needed in decision making, and understanding both man-machine and machine-machine interface requirements. Finally, we are continuing our research in decision theory, knowledge engineering, new and advanced operating systems and systems architectures, AI, and remote sensing. We expect funding to continue to support installation of state-of-the-art equipment and development and organization of experimental facilities.

Army

ORNL research for the Army primarily involves physical, chemical, and toxicological characterization of chemicals (and their degradation products). Examples include diesel fuel, synthetic and alternative fuels, fog oil, dyes, phosphorus formulations, explosives, and sorbent compounds. Funding for Army programs at ORNL has steadily increased, and we expect further increases in the coming years. Studies of the adverse health and environmental effects of diesel fuel and military obscurants were continued in FY 1985, and we anticipate continuing this research and research on other substances in the future. The preparation of database assessment related to munitions production plant wastes will continue, with growth in the development of water criteria reports on several specific waste products to be identified by the Army. Research on techniques and methods for evaluating chemicals and toxicological properties of munition compounds, combustion products, pollution control for explosives, and propellant production will also be undertaken. ORNL also conducts environmental analyses and risk assessment studies relative to chemical munitions demilitarization.

ORNL also continued activities in data systems architecture, management, and analysis for the Army in FY 1985. This supports the DSRD Program discussed on page 62. 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 has continued to provide transportation logistics support to the Armed Forces Command for mobilization of active and reserve units nationwide. ORNL has been successful in researching methods and techniques that allow these agencies to keep pace with rapidly developing technology vital to effective management, decision making, and strategic and logistics 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 DSRD 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, for example, supplementary feedstocks in industrial boilers; validating energy and cost savings of energy conservation projects; performing evaluations and tests of energy conservation equipment, flywheel research, alloys and special materials research to understand defect properties and weapons needs, remote and machine-sensing research, battlefield logistics indexing, and robot systems R&D; developing a technology transfer and inquiry response system to assist facility engineers with energy conservation issues and Energy Conservation Implementation Program validation studies; and assessing district heating efficiency.

Navy

For the Navy and Marine Corps, ORNL conducts R&D analyses related to data systems improvement, instrumentation, engineering, materials, fuel supply and use, energy conservation, and waste disposal. These activities help 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 has been asked to play a major instrumentation and engineering R&D role for the David Taylor Naval Ship R&D Center. ORNL will support the Navy in areas related to hazardous materials management and hazardous waste clean-up technologies development and implementation.

Over the planning period, the major emphases are expected to be (1) instrumentation, systems engineering, and equipment reliability analysis and monitoring and (2) DSRD and technical assistance, especially in the areas of logistics, mobilization planning and modeling, command and control, marine telecommunications, and computer-aided instruction. These activities have resulted in the establishment of a data systems resource management laboratory and microcomputer research center at ORNL, to be used for experimentation with advanced tools and equipment and for prototype system design and modernization efforts. This work is consistent with the emphasis of the DSRD program discussed on page 62.

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, AI, 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 database management methodology with predictive systems analysis techniques is an integral part of Navy technical support activities.

The traditional areas of ORNL R&D in engineering and instrumentation will continue to grow throughout the planning period. Methods and techniques for calibration of Navy systems, studies of the effects of EMP and electromagnetic interference, instrumentation of data acquisition systems, and research on circuit design will also continue.

Other ORNL efforts for the Navy include experimental studies of metastable negative ions, biological and radiation physics research, materials defect research, laser research, engineering testing of key components of Navy-engineered systems and forecasting methods for replacements, cogeneration and district heating studies, and analytical and experimental work related to shipboard heat pumps and waste heat recovery.

Air Force

ORNL carries out work in a variety of areas for the Air Force. Major activities include development of new mathematical algorithms appropriate to pipeline, vector, and array processors; study of swift atom-solid collisions; assessment of potential hazardous waste sites; preparation of radioluminescent lights for remote airfields; development of energy data models for Air Force facilities; and selection criteria for insulating materials. Regional analyses of influence to biophysical regions around Air Force bases will continue. 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 projected.

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 database 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' system responsibilities beyond the 1980s. The systems engineering research and support will consist of research and analysis covering such areas as cost-benefit analysis, design specifications, configuration management, data management, prototyping and benchmarking of on-line systems, data validation, computing security, system verification and validation, system implementation, technical writing, instruction and training, automated data processing systems, site planning for operations, and telecommunications. This and other work is consistent with the emphasis of the DSRD program discussed on page 62.

Other ORNL efforts for the Air Force complement research and analysis discussed in other DOD areas such as modeling emergency and mobilization responses to threats to the United States; engineering testing and methods development for Air Force equipment components; research into energy storage systems; special materials development research, including metal and non-metallic substances; toxic materials and environmental monitoring research to improve standards and techniques; radiation physics research, including particle-solid interactions and electron interaction with communications materials; optical switching research; and basic research into advanced computational techniques, advanced computing systems, and specialized processors.

A principal emphasis of ORNL's support to the Air Force's Engineering and Services organizations regards hazardous chemical and radioactive waste management and site restoration made necessary by past hazardous materials handling practices. The Oak Ridge complex has a great deal of experience and scientific expertise in disciplines related to these issues. However, only recently have such issues impinged heavily on Oak Ridge mission-related operations.

The Laboratory is gaining needed experience and becoming a national center for hazardous chemical waste management solutions through this work. ORNL provides technical support to the Installation Restoration Program and will be providing R&D in various areas of hazardous materials technology. Additionally, the Laboratory will undertake technical environmental and socioeconomic studies.

Strategic Defense Initiative Office

The Oak Ridge complex has extensive experience in many technology areas closely related to the mission requirements being considered in DOD's SDI. Specifically, expertise in the areas of compact, light-weight power and energy storage systems, neutral particle beam systems, and optical components will be applied in the near term.

Oak Ridge will participate in a DOE-led effort to develop and evaluate power and energy storage systems, resulting in a technology development program. In cooperation with other DOE and DOD laboratories and with private industry, ORNL will implement those parts with other organizations. Previous work in neutral particle beam research at ORNL has resulted in the development of negative particle sources having extremely low beam divergence, which will be used to help provide the high-intensity, tightly collimated beam needed for directed energy applications. Oak Ridge expertise in mirror fabrication technology, ion implantation, and radiation testing will support DOD in developing radiation-hardened, passive optical components.

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; (3) for beam systems—ion source design, fabrication and performance testing, RF quadrupole, linear accelerator neutralization, and beam steering studies; and (4) for optical components—precision machining, surface smoothing through ion implantation, and studies of radiation effects on optical properties of mirrors and windows.

Other areas of work that will be pursued include (1) kinetic energy technology—especially high-acceleration testing of electronic components, projectile development, and materials studies; (2) surveillance technology—especially discrimination concepts; (3) computing support; (4) lightweight materials development for space structures; and (5) innovative concepts that can lead to major advancements in defensive system capabilities.

Funding has been modest in FY 1985, and 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.

Defense Nuclear Agency

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. Training is conducted in the use of transport methods, and evaluation and upgrade of nuclear data important to missions of the Defense Nuclear Agency are undertaken. In addition, specific personnel dose response and design-support analyses for difficult problems in radiation shielding are provided. Activities are projected to continue at essentially constant levels.

Department of the Interior

An interagency agreement was initiated in September 1983 to provide the Office of Surface Mining (OSM) of the Department of the Interior (DOI) with technical assistance and research support in the areas of resource management. Under this agreement, ORNL support for OSM will not increase above historic levels during the planning period. In addition, the Laboratory continues to provide support for the U.S. Geological Survey and the Minerals Management Service at a low level of effort; from time to time, ORNL assists DOI in preparing environmental compliance documents required under NEPA (Table 24).

Table 24. Department of the Interior program resource summary

($ in millions—budget authorization)

Major program	Fiscal year			
	1984	1985	1986	1987
Department of the Interior	0.55	0.07	0.07	0.07

Department of Health and Human Services

The Department of Health and Human Services (DHHS) supports research in carcinogenesis, genetics, and toxicology. Its funding is expected to remain reasonably constant through FY 1987 (Table 25). Various branches of the DHHS that support 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 databases in the areas of genetic, reproductive, and general toxicology. We expect additional funding in FY 1986 from the DHHS portion of the superfund money for expansion of our toxicology databases. This effort is designed to assist in assessing the potential human and environmental health risks of hazardous waste cleanup efforts.

Table 25. Department of Health and Human Services program resource summary

($ in millions—budget authorization)

Major program	Fiscal year			
	1984	1985	1986	1987
Department of Health and Human Services	5.84	6.20	6.40	6.80

Environmental Protection Agency

Overall, our EPA program will continue at about the FY-1985 level of effort throughout the planning cycle, with fluctuations in specific program areas (Table 26). 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

Table 26. Environmental Protection Agency program resource summary[a]

[$ in millions—budget authorization (BA)]

Major program	Fiscal year			
	1984	1985	1986	1987
Environmental Protection Agency	4.26	3.60	3.68	3.83

[a]Figures include operating BA and capital equipment.

effort than in previous years. Acidic precipitation research activities are increasing, with major emphasis on the effects of acidic precipitation on agricultural and natural systems and on ion mobility in soils and with integrated assessment support to the National Acidic Precipitation Assessment Program. The Laboratory's role in data analysis for the national surveys of lakes, streams, and soils will increase in FY 1986. ORNL also has the lead role for EPA in planning and organizing research in the Terrestrial Effects of Acidic Precipitation Program. The regional decline of forest species in the eastern United States is being investigated in collaboration with university groups. At the Laboratory, new emphasis centers on using ecosystem models to assess the hazards of chemical releases to aquatic environments. New research in advanced data systems has begun for EPA's Office of Planning, Budget, and Program Management to develop computer analysis capabilities that will allow EPA to better formulate environmental regulatory policy. Current environmental risk analyses terminate in FY 1986, but they may continue under new activities for the Office of Research and Development and the Office of Toxic Substances.

Database development activities for EPA have decreased in 1984 and 1985; however, significant portions of the Environmental Mutagens, Teratogens, and Carcinogens database development will continue to be performed in support of EPA's Office of Toxic Substances programs. Several EPA-sponsored or co-sponsored projects have been initiated to assess indoor air quality or to develop suitable monitoring techniques for such assessments.

ORNL provides technical support to EPA Region IV programs involving restoration and remediation of sites listed on the National Priorities List in the Southeastern United States.

National Science Foundation

The National Science Foundation (NSF), in conjunction with DOE, continues to provide support for the National Center for Small Angle Scattering Research. This national user-dedicated facility 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 linked global element cycles and for the development and application of new methodologies for analyzing ecosystem-level problems. A new thrust is anticipated to research the resiliency of ecosystems to perturbation. ORNL will explore its potential contributions to the planned NSF/DOE/DOI interagency Continental Drilling Program. Another research effort sponsored by NSF involves development of a fiber-optics-based fluoroimmunosenses instrument using monoclonal antibodies and laser-induced luminescence for the detection of trace levels of biological species in body fluids (Table 27).

Table 27. National Science Foundation program resource summary

($ in millions—budget authorization)

Major program	Fiscal year			
	1984	1985	1986	1987
National Science Foundation	1.83	1.44	1.72	1.84

Tennessee Valley Authority

ORNL work for the Tennessee Valley Authority (TVA) in the area of comparative watershed studies is continuing, and a new 5-year effort is being established to use the Controlled Exposure Facility at the 0800 field area to evaluate the effects of O_3 and SO_x on tree seedlings. Other support involves researching the effects of TVA operations on the ecology of reservoirs. Also, TVA is sponsoring or co-sponsoring several indoor air quality research projects. These programs are all expected to continue at roughly the same level throughout the planning cycle (Table 28).

Table 28. Tennessee Valley Authority program resource summary

($ in millions—budget authorization)

Major program	Fiscal year			
	1984	1985	1986	1987
Tennessee Valley Authority	0.27	0.34	0.21	0.22

Federal Emergency Management Agency

ORNL programs for the Federal Emergency Management Agency (FEMA) include a range of research, development, and technical assistance activities in support of national preparedness for major emergencies. At FEMA's request, ORNL serves as an independent center of expertise in areas ranging from engineering assistance to analysis and assessment. Engineering work emphasizes radiation detection and protection and includes developing improved instrumentation, storing certain radiological materials used to test instrumentation, and assisting in hardening civil defense installations against EMP effects. Analysis and assessment activities include building economic models of preparedness options, assisting with the use of computer graphics, working on shelter concepts for emergency protection, forecasting radiation levels from fallout caused by nuclear detonations, developing concepts and handbooks for the

national radiological defense system, and analyzing such issues as evacuation, post-disaster recovery, food reserves, "nuclear winter," responses to warning, ecological problems with contaminated land, expedient supplies of energy and other critical commodities, and data sources for emergency management. These programs are expected to continue at a stable level (Table 29).

Table 29. Federal Emergency Management Agency program resource summary

($ in millions—budget authorization)

Major program	Fiscal year			
	1984	1985	1986	1987
Federal Emergency Management Agency	2.62	1.98	2.75	2.82

Department of Transportation

ORNL's Conservation and Renewable Energy Program serves the Department of Transportation (DOT) as an independent center of expertise, performing work on a variety of small projects that complement and support DOE programs. The work includes (1) modeling and forecasting of highway activities, needs, and travel behavior; (2) computer applications in traffic and transportation research and engineering; (3) highway statistics and traffic data systems management and analysis; and (4) highway network studies. ORNL expects to continue to provide technical support to DOT throughout the planning cycle as a center for research related to transportation energy issues, network and traffic research, and systems planning (Table 30).

Table 30. Department of Transportation program resource summary

($ in millions—budget authorization)

Major program	Fiscal year			
	1984	1985	1986	1987
Department of Transportation	0.30	0.31	0.40	0.53

Department of Education

Tasks for the Department of Education (ED) continue to include review and analysis of the Department of Education Financial Management Information System (EDFMIS) for compliance with a Presidential Directive (REFORM '88). The REFORM '88 program is the review and updating of all governmental management information systems by the end of FY 1988. The ED has one of the oldest management information systems within the federal government (dating

from 1973), and extensive analysis of actual ED data needs is necessary before a review of the system itself. Our work is expected to include analysis of the entire EDFMIS by functional module (e.g., ledger, accounts, etc.) (Table 31).

Table 31. Department of Education program resource summary

($ in millions—budget authorization)

Major program	Fiscal year			
	1984	1985	1986	1987
Department of Education	0.12	0.25	0.10	0.10

Department of Justice

Research support for data systems activities by the Department of Justice continued in FY 1984. Although most of this 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 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, particularly energy data analysis and assessment for the Antitrust Division, may be included as this program continues to evolve. 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 32).

Table 32. Department of Justice program resource summary

($ in millions—budget authorization)

Major program	Fiscal year			
	1984	1985	1986	1987
Department of Justice	0.45	0.67	0.55	0.50

Department of Labor

Tasks for the Department of Labor (DOL) continue to include research analysis and cost-benefit analysis of adapting Air Force software used by ORNL staff to develop a production Navy Civilian Personnel Data System (Table 33). The software is being used by the Navy as part of an interactive on-line data system available to more than 140 sites around the world. The number of personnel records in the Navy system will total more than 350,000. The DOL

Table 33. Department of Labor program resource summary

($ in millions—budget authorization)

Major program	Fiscal year			
	1984	1985	1986	1987
Department of Labor	0.00	0.10	0.10	0.00

has asked ORNL staff to test the capability of the Air Force software to meet DOL personnel data needs (28,000 total records with 18,000 active files) without the development of new "customized" computer code. The use of common software, if practical in this application, would produce significant cost savings for the government.

Agency for International Development

ORNL serves as the center of expertise for the Office of Energy, AID, on technical aspects of energy planning and energy technology (Table 34). ORNL's work includes research and analysis; technical assistance in project development, implementation, and evaluation related to energy planning, renewable energy technologies, and fossil energy technologies; and information dissemination.

Table 34. Agency for International Development program resource summary

($ in millions—budget authorization)

Major program	Fiscal year			
	1984	1985	1986	1987
Agency for International Development	0.74	1.17	1.00	1.00

Other Federal Agencies

ORNL also provides technical support to a variety of other federal agencies. The Consumer Product Safety Commission, DOI, NASA, the National Oceanic and Atmospheric Administration, and the Department of Agriculture all support small amounts of life sciences research. Some support for FY 1985 is also coming from the U.S. Department of State for work performed for IAEA. Energy conservation program evaluation and energy demand analysis are continuing for the Bonneville Power Administration. Collaborative research for the Park Service is beginning at the Great Smoky Mountains National Park (Table 35).

Table 35. Other federal agencies program resource summary

($ in millions—budget authorization)

Major program	Fiscal year			
	1984	1985	1986	1987
Other federal agencies	2.17	0.70	1.69	1.95

Nonfederal Organizations

Electric Power Research Institute

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 impacts 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 new initiative establishes a lead role for ORNL in EPRI's new major thrust on the effects of acid deposition on forest soils. The Laboratory is also working with EPRI to establish a facility for the testing and evaluation of cool storage systems for commercial buildings. Various types of ice storage systems will be tested in cooperation with manufacturers according to a uniform set of test procedures. The test results will be used by EPRI, manufacturers, and engineers to improve cool storage system designs. The facility will draw from the extensive experience and facilities at ORNL, represented by the Thermal Energy Storage Program and the BER Program, and will be of direct benefit to these DOE programs (Table 36). EPRI is participating in the DOE/ORNL AACE and is generally interested in work of the Power Systems Technology Program.

Table 36. Electric Power Research Institute program resource summary

($ in millions—budget authorization)

Major program	Fiscal year			
	1984	1985	1986	1987
Electric Power Research Institute	1.88	2.35	2.55	2.50

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. Current nonfederal sponsors include such entities as the United Kingdom's Atomic Energy Agency; JAERI; the Canadian Atomic Energy Commission; the National Institute of Radiation Protection of Sweden; the universities of Tennessee, Georgia, Illinois, Maryland, and Wyoming; the Illinois Natural History Survey; the states of California, Maryland, and Alaska; the Gas Research Institute; Metropolitan Edison/General Public Utility; the Florida Institute of Phosphate Research; Gulf Oil; Goodyear Atomic; Battelle Laboratories, EG&G; General Electric; the American Petroleum Institute; Harvard University; and the Technology for Energy Corporation. Also, new work for the National Association of Home Builders Research Foundation was begun to assist in the design of an artificially intelligent home control system. During FY 1985, the ORNL fusion program received 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 1985 is estimated at about $4.1 million (Table 37).

Table 37. Miscellaneous nonfederal program resource summary

($ in millions—budget authorization)

Major program	Fiscal year			
	1984	1985	1986	1987
Other nonfederal organizations	4.41	4.13	4.34	3.42

Site and Facilities

SITE AND FACILITIES

Site Development

The late 1980s and early 1990s are projected to be a period of stable overall funding and resource requirements. Some change in the size and direction of specific programs is projected, but this is not envisioned to affect overall facility requirements materially. These near-term (next 5 years) program trends indicate that the Laboratory will continue to require most of its existing facilities throughout the period. Centralization of a few Laboratory activities into the Energy Systems organization (resulting in relocation away from ORNL) and consolidation of other activities into better, more adequate facilities are projected to continue. However, this will not eliminate most of the long-standing facilities deficiencies, nor will it address the age of Laboratory facilities (nearly 80% are more than 30 years old) with their associated obsolescence and worn-out conditions. An aggressive long-term revitalization effort, including both programmatic and general-purpose facilities, is required.

The Laboratory's strategic view, presented in a preceding section, describes the evolution of long-term (next 15 years) program trends. Major growth is projected in technology areas with emphasis on fission, fossil, defense, and wastes. An overall increase in funding and personnel in the range of 20% to 50% will be needed to fulfill this strategic view. In addition, some shift in program sponsorship is envisioned, with DOE support projected to comprise about two-thirds of the total in the year 2001. This strategic view reinforces the need to revitalize the Laboratory's existing facilities and suggests that some additional facilities would be required to house these expanded activities.

Preliminary planning for housing increases in DOD-sponsored activities indicates that they would be located in less-than-fully-utilized facilities at ORNL and Y-12 and/or in facilities made available by the shutdown and placement in standby of ORGDP. Work accomplished at the ORNL Bethel Valley site is projected to be absorbed mostly within existing facilities.

Most remaining increases in research (both DOE and WFO) that require laboratory space will be absorbed within existing ORNL laboratories at the Bethel Valley site and at Y-12. However, the Laboratory currently has a significant deficit of adequate office space, and currently planned construction projects will only eliminate this deficiency. Increased programmatic activity will require additional office space (especially at the Bethel Valley site). Unique or special-purpose facilities, required by new research initiatives such as the CNR, will also have to be provided. Because the planned growth is projected to be distributed among the three Oak Ridge installations (ORNL, Y-12, and ORGDP), all of which have previously supported larger programs, the overall impact on existing general-purpose facilities and utilities of these sites will be small if planned and budgeted revitalization continues.

Primary objectives of the Site Development Plan throughout the planning period are to maintain existing adequate facilities, upgrade currently inadequate facilities through rehabilitation and selected replacement, and provide additional facilities when required to overcome existing space deficiencies, to meet new research initiatives, and to bring the site into compliance with currently evolving environmental regulations. Major emphasis is being placed on facil-

ities in the Bethel and Melton valleys (X-10) site; this includes continued development of the Life Sciences Complex that would permit 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 replacement facilities construction will occur in Bethel and Melton valleys, while utility and building restoration will occur there and at the ORNL facilities located at Y-12. A few new special-purpose facilities are required to house some elements of our planned research. Numerous tasks associated with environmental restoration and upgrade will be accomplished. No specific work at ORGDP has yet been defined because of the very preliminary nature of program plans for work that would be located there.

Facilities Plans: 1986–91

Multiprogram Energy Laboratories Revitalization Project

In late 1984 and early 1985, ORNL participated in development of the Multiprogram Energy Laboratories (MEL) Revitalization Project. Existing facilities and requirements were surveyed, and current deficiencies were listed. Most of these had been previously identified, and many were included in the Laboratory's previous 5-year Multiprogram General-Purpose Facilities (MGPF) program plans.

As a result of new criteria for inclusion in the Revitalization Project, some tasks were redefined, accelerated, decelerated, combined with others into logical groupings, or otherwise modified, which makes complete traceability to the MGPF program difficult. Initially included in the Revitalization Project were 17 ORNL subprojects totaling about $160 million to be initiated between FY 1987 and 1991. The Laboratory has identified an additional $30+ million, which it is requesting be included with the revitalization activities. The specific projects are shown in Table 38.

Major elements of the Revitalization Project at ORNL include rehabilitation of the Central Research Complex (4500 area buildings) ($40+ million), restoration of ORNL's planned long-term facilities at the Y-12 site ($40+ million), and construction of several office and office-laboratory structures (nearly $50 million) to eliminate existing overcrowding and use of grossly inadequate facilities. An economic evaluation of the proposed new and replacement facilities indicates they will provide major operating and maintenance cost savings and significantly improve the productivity of those impacted. Paybacks in the 3- to 5-year range are projected for these facilities.

General Plant Projects

The overall GPP needs of the Laboratory are summarized in Table 39. This table reflects a wide range of sources of support, several of which are new this year. The KG (Environmental Compliance) support will provide much-needed relief to the AT (General Laboratory) support, which has funded numerous environmental projects in recent years. In addition, the KG (Facilities) support is intended to supplement the general GPP and address existing general-purpose deficiencies as part of DOE's MEL Revitalization Project. The HA support is addressing a critical one-time need in Biology facilities. The WB support will deal with energy retrofit projects and with enhancing the capabilities of our proposed FY-1988 Energy Monitoring and Control System project. The AR (Waste Management) support will continue vital work in concert with our environmental compliance and operational needs.

Table 38. Major construction projects by fiscal year

($ in millions)

Title	Fiscal year							Total estimated cost
	1985 and before	1986	1987	1988	1989	1990	1991	
Funded and budgeted construction								
Program-related projects								
HTML[a]	16.4	2.8						19.2
ARIM,[b] HFIR[c] heat exchanger	0.3							0.3
ARIM, HFIR heat exchanger and Remote Sampling Facility		0.8	0.4					1.2
AIM,[d] 25-MV tandem extended tube upgrade		0.5						0.5
Central Waste Disposal Facility		1.0		6.5				7.5
Nonradiological wastewater treatment system		3.0	15.0					18.0
MGPF[e] projects								
Cooling water facilities restoration	3.2							3.2
Environmental monitoring systems upgrade, phase I	1.0	2.5						3.5
Environmental monitoring systems upgrade, phase II		5.0	0.3					5.3
Primary electrical distribution system restoration	0.8	1.4						2.2
Central chilled-water system restoration	1.0	2.2	1.5					4.7
Total funded and budgeted	22.7	19.2	17.2	6.5				65.6
Proposed projects								
Program-related projects								
Analytical Mass Spectrometry Laboratory			0.7	4.2				4.9
ARIM, HFIR Critical Facility			0.3					0.3
AIM, ORELA[f] beam lines			0.3					0.3
Solid State Sciences Research Facility[g]					4.0	5.0		9.0
Center for Neutron Research[h]		2.0	6.0	10.0	14.0	40.0	60.0	312.0
Health and Safety Research Laboratory			3.5					3.5
Mammalian Genetics Research Facility[i]			2.5	12.5	9.0			24.0
Upgrade air supply, part I			3.2					3.2
Upgrade air supply, part II				3.0				3.0
RH-TRU[j] Waste Handling Facility					5.0	30.0		35.0
Facility modification for RH-TRU volume reduction				3.0				3.0
Replace liquid low-level waste system				20.0	35.0	25.0		80.0
Low-level waste transfer and processing system					12.0			12.0
Heavy ion cooling ring				6.0				6.0
Heavy ion booster synchrotron and storage ring					12.0	15.0	12.0	39.0
MEL-GPF[k] projects								
Upgrade steam distribution system			2.5	4.3				6.8

Table 38 (continued)

Title	Fiscal year							Total estimated cost
	1985 and before	1986	1987	1988	1989	1990	1991	
Upgrade fire protection, Oak Ridge National Laboratory (ORNL) at Y-12		1.8						1.8
Central Administrative and Support Building			0.8	4.6				5.4
Utilities restoration, piping systems (ORNL at Y-12)			3.8					3.8
Electrical systems upgrade			3.0					3.0
Buildings piping system upgrade				4.4				4.4
Multiprogram Support Building[l]				2.5	10.9	3.8	1.1	18.3
Support facilities upgrade				6.5				6.5
In-house energy management project, Energy Monitoring and Control System[m]				3.0				3.0
Roads and parking lots, modifications and additions					3.0			3.0
Central heating systems upgrade					5.1			5.1
Multiprogram Laboratory and Office Facility I, restoration					2.3	11.2		13.5
Central Research Complex, mechanical systems restoration					5.7	23.9		29.6
Hot Cell Facility restoration[n]					5.7	5.7	5.8	17.2
Measurements and Control Research Facility						2.3	7.4	9.7
Multiprogram Laboratory and Office Facility II, restoration						1.2	9.2	10.4
Central Research Complex, electrical systems restoration						2.5	15.1	17.6
Potable water system upgrade						1.1	5.0	6.1
Multiprogram Laboratory and Office Facility III, restoration[o]							2.6	20.3
Technical Support Facility[o]							2.4	14.8

[a]HTML = High-Temperature Materials Laboratory.
[b]ARIM = Accelerator and Reactor Improvement and Modification.
[c]HFIR = High-Flux Isotope Reactor.
[d]AIM = Accelerator Improvements and Modifications.
[e]MGPF = Multiprogram General-Purpose Facilities.
[f]ORELA = Oak Ridge Electron Linear Accelerator.
[g]Formerly called Surface Sciences Research Facility.
[h]Formerly called HFIR-II. The total amount shown includes funding that extends beyond FY 1991.
[i]Costs for this project have been reduced as a result of a recent scope change and cost estimate. The title has been changed from the Toxic Substances Laboratory and Animal Facility to describe more accurately the intended use of the facility.
[j]RH-TRU = Remote-handled transuranic.
[k]MEL-GPF = Multiprogram Energy Laboratory—General-Purpose Facility.
[l]This project is a reconfiguration of the previous West Core Facilities project.
[m]This basic installation will be expanded with FY 1989-91 WB program General Plant Project funding.
[n]This project is not currently in the MEL-GPF Revitalization Project. It may be accomplished ultimately with programmatic or some other funding source.
[o]The total amount shown includes funding that extends beyond FY 1991.

Table 39. General Plant Project (GPP) funding needs through FY 1991

($ in millions—budget authorization)

	Fiscal year						
	1985	1986	1987	1988	1989	1990	1991
General Laboratory GPP (AT Program)	7.0[a]	8.0[b]	8.7[c]	6.0[d]	6.0[d]	6.0[d]	6.0[d]
Facilities Support (KG Program)	-	-	4.6[d]	5.0[d]	5.0[d]	5.0[d]	5.0[d]
Environmental Compliance (KG Program)	-	5.0	6.9	4.2	2.5	-	-
Waste Management (AR Program)	2.4	2.4	3.7	3.0	3.2	3.2	3.2
Life Sciences (HA Program)	-	0.5	-	-	-	-	-
Energy Conservation	0.0	0.0	0.0	0.5	2.0[e]	2.0[e]	2.0[e]
Total GPP funding	9.4	16.2	23.9	18.7	18.7	16.2	16.2

[a]Of this amount, $3.4 million is to be used to address critical environmental issues.

[b]Of this amount, $3.6 million is to be used to address critical environmental issues.

[c]This amount is as shown in ORNL budget request; if the Laboratory Revitalization Project occurs as presented in the *DOE Multiprogram Energy Laboratories—General Purpose Facilities Program Plan*, the figure would be $5.1 million.

[d]These amounts are based on a successful initiation of the Laboratory Revitalization Project and the inclusion of Facilities Support GPP Funds.

[e]This amount includes support for the proposed Energy Monitoring and Control System.

The proposed MEL Revitalization Project will also have a positive impact on GPP. Acceleration of the rehabilitation of our existing facilities via proposed line item projects will reduce the need for GPP during the planning period. Last year's Institutional Plan reflected a need increasing to a peak of $21 million in FY 1988 and 1989. With implementation of the Revitalization Project, the corresponding need in FY 1988 and 1989 would be reduced to $11 million (General Laboratory—$6 million; Facilities Support—$5 million).

General-Purpose Equipment

Overall general-purpose equipment needs of the Laboratory are reflected in Table 40. The levels shown in FY 1987 and beyond are those required to reduce the severe backlog of over-age, obsolete equipment at the Laboratory. Once this is accomplished (FY 1992), the funding requirements to maintain the inventory will be about $5 million per year.

The categories of equipment and our backlog of obsolete equipment are shown in Table 41. Of our existing inventory of shop equipment, 73% is obsolete; 70% of our heavy equipment is obsolete. These two categories alone constitute a $15.2-million need.

Table 40. General-purpose equipment funding needs through FY 1991

($ in millions)

	Fiscal year						
	1985	1986	1987	1988	1989	1990	1991
AT Program	3.8[a]	11.3[b]	17.0	10.5	10.5	10.5	10.5
KG Program		1.0	2.6	1.3	1.3		

[a]Of this amount, $2.6 million is included to address critical environmental issues.

[b]Of this amount, $2.5 million is included to address critical environmental issues.

Table 41. General-purpose equipment (GPE) inventory—1985

($ in thousands)

Category	Total GPE inventory	Total GPE backlog
Computer	12,150	3,500
Office	1,085	300
Shop	17,775	13,000
Vehicle	8,625	4,400
Laboratory	4,450	2,000
Heavy equipment	3,140	2,200
Security	120	100
Miscellaneous	6,655	1,500
Total	54,000	27,000

Requirements for Computing Equipment

The computational resources available to researchers at ORNL continue to lag behind their needs both in capacity and in capability, but our senior management is working with DOE to remedy this situation. Scientific and technical computing is critically important to the Laboratory, and the Office of the Contractor's Representative has asked ORNL to take the lead role in planning for scientific and technical computing for Energy Systems.

ORNL has recently completed a strategic plan for computing that emphasizes scientific and technical computing. This plan is part of a larger plan covering all of Energy Systems. The Energy Systems long-range strategy defines three separate categories of computing: dedicated, administrative, and scientific/technical. Dedicated computing consists of computing done by processors attached to equipment. Planning for this kind of computing will be the responsibility of the end user unless a need exists for networking to other systems. The Energy Systems plan envisions separate distributed computing systems for administrative data processing and for technical computing.

A Distributed Scientific and Technical Computing System

A committee of scientists and engineers representing scientific and technical computer users at ORNL and other parts of Energy Systems has planned a distributed computing system that they believe will lead to significant increases in productivity and creativity of the Energy Systems technical staff. The plan emphasizes interactive and distributed computing and recognizes the need for users to access a variety of computing resources including high-capability machines. The plan also emphasizes the need for a coherent system that is simple enough to be supported and that provides a "user friendly" computing environment.

The plan calls for a multi-level computing environment. At the lowest level is the individual user work station. Initially, this role will be played by terminals and by personal computers. It is expected that within a few years the computational power of microcomputers will increase sufficiently and the cost will decrease sufficiently that these workstations will have the power of today's "super-mini" computers or low-end mainframes.

The next level in the hierarchy is group or divisional level machines of the mini or super-mini class that primarily serve groups working together on a single project or similar projects. These machines would allow the sharing of expensive peripherals such as high-speed printers and could serve as hosts to specialized equipment such as attached processors.

The third level will consist of a central interactive computing facility. This facility will be modular in design so that it can be easily expanded to maintain good responsiveness. It will serve as a focus for software distribution and as a computing resource for staff members who need capabilities that exceed those of the level 1 or level 2 machines or who cannot justify the acquisition of such machines. Bids for a machine to serve in this capacity have been received and are being evaluated.

The highest level of capability in the distributed system will be supercomputers. Some ORNL users currently have access to the CRAY computers operated for the OER by the National Magnetic Fusion Energy Computing Center at LLNL. Others will soon have access to the CRAY XMP located at ORGDP. A plan is being developed to give uncleared personnel access to the ORGDP CRAY for at least part of each day so that all ORNL scientists and engineers will have some access to a high-capability computer.

A distributed computing system can be most effective if it is planned in a coherent fashion. The user committee has paid careful attention to issues of ease of use and user productivity. It is extremely important to limit the number of operating systems and networking protocols so that the system will be easier to support and the user will find it easier to switch an application between machines. Levels 1 through 3 of the system will be limited to two operating systems, VMS and UNIX, and to two networking protocols DECNET and TCP/IP. It will be difficult to integrate a supercomputer into the system now because none of the supercomputers used by ORNL is under its control. ORNL must work with DOE to acquire a supercomputer in FY 1988 so that a truly high-productivity computing environment can be constructed.

Networks

The Oak Ridge data network, a high-speed network based on broad-band cable television technology, will serve as the backbone of a data network that will connect the various parts of the distributed scientific and technical computing system. Current plans call for the distributed systems to connect to several Ethernet local area networks (LANs). These Ethernet LANs will then be connected to the broad-band backbone via gateway devices. A networking test bed is

being built to test these ideas and to test equipment to ensure compatibility with the network. The test bed will also be used to verify that systems using DECNET can communicate with those using TCP/IP via a micro VAX that runs both protocols simultaneously.

Research in Parallel Computing

Recent advances in very large scale integration have made it possible to build more and more powerful computers on a single silicon chip. The power of the newest chips will approximate that of mainframes that are only a few years old. The computing power of larger computers has not increased so rapidly, however, and it is generally accepted that the most cost-effective way of building extremely powerful computers is to use many smaller processing units working together in parallel to solve a single problem. Unfortunately, this is a very complicated undertaking. ORNL, however, has made great progress recently in the area of developing algorithms to take advantage of parallel processing architectures.

Many experts expect the next generation of supercomputers to use large numbers of relatively small processors. ORNL has acquired two machines with this architecture and is learning how best to use this type of machine and what types of problems it is best suited to solving. ORNL plans to acquire a large, massively parallel computer in FY 1988 and make it available to researchers at ORNL and throughout DOE through the OER Computer Network.

External Interactions

EXTERNAL INTERACTIONS

University Programs

Interactions between the Laboratory and the university community continue to provide a two-way flow of technical information through programs and informal association. The DOE University-Laboratory Cooperative Program, OER, funds university relations activities at both ORNL and the Oak Ridge Associated Universities (ORAU). The program has been funded at the same level for a number of years, and the numbers of participants accommodated in both the ORNL and ORAU programs continue 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, even though the majority receive financial support from the Laboratory's operating divisions and other sources (such as colleges and universities, fellowships, and grants).

DOE supports a variety of university programs at ORNL. Ongoing subcontracts with several college consortia give undergraduate students the opportunity to receive college credit for a semester of research work and classes at ORNL. Other programs are available for undergraduate students, including reactor training cooperative experiments, student research participation opportunities, and technology internship for candidates for Associate of Arts degrees. New programs in secondary education provided a summer field experience for area high school teachers and a computational sciences workshop for state high school honors students.

Outreach efforts have been initiated in conjunction with ORAU to better acquaint universities with opportunities at ORNL. These efforts will include conferences and workshops in addition to increased site visitations. A strong effort is under way in support of increased interactions with HBCUs.

For a number of years, minorities from the 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 professional positions. The Special Summer Program for undergraduates in science and engineering provided appointments for several students from HBCUs in the summer of 1985. ORNL has also participated for 11 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. The Laboratory also 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 ESD is under way in the biomass and CO_2 areas. A long-term program of interaction with Lincoln University

(Pennsylvania), Alabama A&M University, and Knoxville College in the defense waste management area is being developed by the ORNL Energy and Chemical Technology divisions. The initial focus of the Knoxville College program is a 3-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 subcontract was awarded recently to North Carolina A&T State University to test and evaluate advanced ceramics. A major subcontracting effort is continuing at Atlanta University in support of the Fusion Program.

Technology Transfer Program

Overview of Existing Program

The Office of Technology Applications (OTA) has examined the existing technology transfer functions at Energy Systems. We have developed and implemented new standard practice procedures to coordinate and improve each step of the process. New procedures include

- a technology transfer assessment and development process—for determining the transfer potential of inventions;
- awards for inventions—a schedule of cash awards to inventors for patent applications;
- royalties from licensing—a means for sharing royalty income with the inventors named on licensed patents; and
- intellectual property rights—covering employees' rights and responsibilities in reporting all inventions developed in the course of their employment at Energy Systems.

To further stimulate our inventive employees, we have instituted other measures in addition to the cash awards for patent applications and the sharing of royalties with inventors. We have created the Inventors' Forum to encourage exchange of ideas and to facilitate intersite communications. The Forum is an employee-managed organization of all Energy Systems patent holders. The kickoff meeting of this organization was held April 30 at the annual patent luncheon. A new feature of this awards luncheon was also introduced—Inventors' Forum lapel pins to recognize Energy Systems patent holders.

Recognizing that most technology transfer occurs from one-on-one interactions between our researchers and industry's, we have taken steps to allow and encourage these types of exchanges. It is our belief that we can accelerate technology transfer by freeing our people to perform as consultants to outside firms. We recently implemented a revision of our consulting policy consistent with DOE's desire to further liberalize the employees' ability to engage in these interactions outside the course of their normal work activities.

Evidence abounds to show that the process of technology transfer is already accelerating in Oak Ridge.

- Inventions disclosures are up over 15% during our first 9 months of performance—reversing a 5-year declining trend.
- Publications are up 5%—also a trend reversal.
- Since the fall of 1984, nine workshops or conferences related to technology tansfer have been presented—a 50% increase over FY 1984—with a combined attendance of 2400.

- Energy Systems now has 60 Technical Bulletins in the preparation and publication stages; 1985 will be the biggest year ever in bulletin publication by a factor of 2.
- A large number of inquiries have been received from commercial firms, many of which are inquiring of Oak Ridge for the first time.
- Even though Energy Systems has not yet received title to the intellectual property, we are in the process of prenegotiating licenses with several commercial firms.

The OTA has been identifying technologies with commercial potential, documenting current status, and then developing marketing strategies for them. As a result of our initiatives, we have begun to take action on nearly 50 different technologies with commercial value. We believe that about half of these have near-term commercial potential.

In 1984, DOE agreed to give ORNL $100,000 on a matching basis to identify commercially promising developments and allow additional work to bring the technology to a stage where industry could make an assessment of its true commercial potential. In FY 1985, the OTA funded seven ORNL technologies for further development; total funding for these was $228,000. Funding and staffing levels for the Office of Research and Technology Analysis are shown in Table 42.

Table 42. Estimated staffing and expenditures for the Office of Research and Technology Analysis (ORTA)[a]

	Fiscal year						
	1985	1986	1987	1988	1989	1990	1991
	Funding, $ in thousands						
ORTA[b]	607	917	963	1,023	1,074	1,128	1,184
Other	11,000	11,000	11,000	11,000	11,000	11,000	11,000
Total	11,607	11,917	11,963	12,023	12,074	12,128	12,184
	Staffing, full-time equivalents						
Professional							
ORTA	3	4	4	5	5	5	5
Other[c]	60	60	60	60	60	60	60
Total	63	64	64	65	65	65	65
Support	2	2	2	2	2	2	2

[a]A 5.0% inflation factor has been used between FY 1985 and 1986 and between FY 1986 and 1987. For FY 1988–91, amounts are in constant FY-1987 dollars.

[b]These funds are for the Oak Ridge National Laboratory (ORNL) office of the Martin Marietta Energy Systems, Inc., Office of Technology Applications, which includes ORNL, the Y-12 Plant, Oak Ridge Gaseous Diffusion Plant, and Paducah Gaseous Diffusion Plant.

[c]Estimated.

A new initiative supported by DOE is the Industry Technology Exchange Research Program. This program supports visiting research appointments at ORNL for scientists and engineers currently working for industry. This program allows the visiting researcher to work side-by-side with our staff members to give them exposure to our developments and hands-on

experience with the technology. This process is expected to help deepen the understanding of new technology and speed the adoption process when the researcher returns to his company. Two such researchers are now on site: one from CPC International working in the Biology Division on anaerobic enzymes for food processing and one in the Metals and Ceramics Division working on metal-to-ceramic joining.

Admittedly, the ultimate commercial potential for many of our technologies spans a wide range from a few million dollars in sales to possibly over $100 million, if our market studies of the nickel-iron aluminide alloys are correct. It should be noted, however, that some of the technologies developed at the Energy Systems facilities do have the potential of changing basic industries within the United States and strengthening our competitive position in the international marketplace.

To capitalize on the wealth of technical talent and expertise in materials science at national laboratories, a consortium of U.S. steel companies, including Bethlehem, U.S. Steel, Armco, National, and LTV, is working with ORNL and ANL. They will attempt to develop breakthrough technologies, which could help the domestic steelmakers regain their competitive position in world steel markets. One thrust of the program will be to find new ways to convert iron ore into liquid metal, bypassing the expensive coking ovens and blast furnaces now used. Another focus will be on casting liquid metal into pieces close to the dimensions of the final product. One possibility is to use powerful magnetic fields to confine the molten metal so it can be cast into thin sheets, eliminating the need for strip mills to flatten thick billets. ORNL's fusion program will contribute its magnet expertise to the problem of casting steel.

Appendix. Resource Projections

Table A.1. Laboratory funding summary by fiscal year[a]

($ in millions)

	1985		1986		1987		1988		1989		1990		1991	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
Department of Energy effort	302.0	298.2	314.6	304.8	366.1	344.9	365.1	357.8	357.8	355.7	358.3	355.6	357.4	355.2
Work for others	148.4	100.3	122.9	111.6	159.5	144.9	166.0	151.0	165.2	150.7	165.8	151.4	166.5	152.1
Total operating	450.4	398.5	437.5	416.2	525.6	489.8	531.1	508.8	523.0	508.4	524.1	507.0	523.9	507.3
Capital equipment	22.5		27.0		35.7		32.6		32.9		33.2		33.2	
Program construction														
Funded/budgeted	7.0		3.2											
Proposed			6.8		36.9		69.6		139.7		85.0		72.0	
General-Purpose Facilities														
Funded/budgeted	5.2		7.8											
Proposed					11.9		25.3		32.7		51.7		46.2	
General Plant Projects (AT, AR, KG, HA, and WB)	9.4		15.7		23.9		21.2		18.7		16.2		16.2	
General purpose equipment (AT and KG)	3.8		12.3		19.6		11.8		11.8		10.5		10.5	
Total Laboratory funding	498.3		510.3		653.6		691.6		758.8		720.7		702.0	

[a]Escalation factors are 7%; FY-1988–91 amounts are in constant FY-1987 dollars. BA = budget authorization; BO = budget obligation.

Table A.2. Laboratory personnel summary by fiscal year

(Full-time equivalents)

	1985	1986	1987	1988	1989	1990	1991
Direct							
Department of Energy effort	1537	1534	1610	1595	1552	1567	1581
Work for others	518	650	851	879	877	878	879
Isotopes	49	48	48	48	48	48	48
Total technical	2104	2232	2509	2522	2477	2493	2508
Other direct[a]	358	355	367	365	361	366	365
Total direct	2462	2587	2876	2887	2838	2859	2873
Indirect	2532	2685	3018	3034	2980	2999	3017
Total Laboratory personnel	4994	5272	5894	5921	5818	5858	5890

[a]Includes Computing and Telecommunications Division, Engineering Division, Y-12 Plant, and Oak Ridge Gaseous Diffusion Plant personnel charged to the Oak Ridge National Laboratory.

Table A.3. Funding by Assistant Secretarial Level Office

($ in millions)

	FY 1985		FY 1986[a]		FY 1987[a]		FY 1988[a]		FY 1989		FY 1990		FY 1991	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
Assistant Secretary for Fossil Energy														
Total Operating	7.1	7.4	8.3	7.9	7.7	7.9	7.7	7.9	7.7	7.9	8.5	8.7	9.3	9.5
Capital Equipment	0.0		0.0		0.0		0.0		0.0		0.0		0.0	
Total Asst Secretary	7.1		8.3		7.8		7.8		7.8		8.5		9.3	
Assistant Secretary for Nuclear Energy														
Total Operating	41.0	40.4	37.0	36.3	41.5	40.6	38.6	37.6	38.1	37.1	40.3	38.8	40.6	39.6
Capital Equipment	1.8		0.6		1.1		1.1		1.4		1.4		1.2	
Total Asst Secretary	42.8		37.6		42.7		39.7		39.6		41.7		41.9	
Assistant Secretary for Conservation and Renewable Energy														
Total Operating	38.1	41.3	44.2	43.9	59.0	53.5	61.5	56.6	58.6	58.8	56.6	56.8	54.6	54.8
Capital Equipment	3.9		4.3		3.0		1.8		1.5		1.5		1.5	
Construction	6.5		2.7		0.0		0.0		0.0		0.0		0.0	
Total Asst Secretary	48.4		51.2		61.9		63.3		60.1		58.1		56.1	
Office of Energy Research														
Total Operating	162.6	156.0	170.5	161.0	198.2	185.0	202.3	201.0	203.3	202.0	204.0	202.7	204.9	203.6
Capital Equipment	12.7		14.9		18.7		17.5		17.5		17.9		18.2	
Construction	0.3		0.5		0.0		0.0		0.0		0.0		0.0	
Total Asst Secretary	175.6		185.9		216.9		219.8		220.9		221.8		223.1	

Table A.3 (continued)

	FY 1985		FY 1986[a]		FY 1987[a]		FY 1988[a]		FY 1989		FY 1990		FY 1991	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
Assistant Secretary for Defense Programs														
Total Operating	29.3	27.8	34.6	33.8	41.1	39.0	36.5	36.5	31.6	31.6	30.6	30.6	29.6	29.6
Capital Equipment	2.0		2.0		3.1		2.1		2.2		2.2		2.0	
Total Asst Secretary	31.3		36.5		44.2		38.6		33.8		32.7		31.6	
Assistant Secretary for Environment, Safety, and Health														
Total Operating	2.4	3.6	2.9	3.0	3.1	3.1	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
Federal Energy Regulatory Commission														
Total Operating	0.8	0.8	0.8	0.8	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	0.0	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 Adminstration														
Total Operating	2.3	1.6	1.0	2.5	1.0	1.2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Office of Policy, Planning, and Analysis														
Total Operating	0.2	0.3	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

	FY 1985		FY 1986[a]		FY 1987[a]		FY 1988[a]		FY 1989		FY 1990		FY 1991	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
Office of Civilian Radioactive Waste Management														
Total Operating	3.6	3.3	4.4	4.1	4.1	4.1	4.1	4.1	4.0	4.0	3.9	3.9	3.9	3.9
Capital Equipment	0.0		0.1		0.0		0.0		0.0		0.0		0.0	
Total Asst Secretary	3.6		4.4		4.2		4.1		4.0		3.9		3.9	
Assistant Secretary for Management & Administration														
Total Operating	1.2	1.2	1.2	1.2	1.3	1.2	1.3	0.9	1.3	0.9	1.3	0.9	1.3	0.9
Capital Equipment	0.1		0.1		0.1		0.1		0.1		0.1		0.1	
Total Asst Secretary	1.3		1.3		1.4		1.4		1.4		1.4		1.4	
Assistant Secretary for Congressional, Intergovernmental, & Public Affairs														
Total Operating	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DOE CONTRACTORS & OPERATIONS OFFICES														
Total Operating	13.3	14.5	9.7	10.0	8.1	8.2	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Capital Equipment	0.4		0.3		0.1		0.0		0.1		0.1		0.1	
Total Program	13.7		10.0		8.2		8.0		8.1		8.1		8.1	

Table A.3 (continued)

	FY 1985		FY 1986[a]		FY 1987[a]		FY 1988[a]		FY 1989		FY 1990		FY 1991	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
Total DOE Programs														
Total Operating	302.0	298.2	314.6	304.6	366.1	344.9	365.1	357.8	357.8	355.7	358.3	355.6	357.4	355.2
Capital Equipment	20.8		22.3		26.3		22.7		22.9		23.2		23.2	
Construction	6.8		3.2		0.0		0.0		0.0		0.0		0.0	
Total DOE Programs	329.6		340.1		392.3		387.9		380.7		381.5		380.6	
DEPARTMENT OF DEFENSE														
Total Operating	20.1	16.0	45.6	43.4	77.6	75.6	82.9	80.9	82.0	79.9	82.4	80.4	82.9	80.9
Capital Equipment	0.5		3.7		8.6		9.2		9.3		9.3		9.3	
Total Asst Secretary	20.6		49.3		86.3		92.1		91.3		91.7		92.2	
DEPARTMENT OF DEFENSE DATA SYSTEMS														
Total Operating	73.9	30.6	27.1	17.8	31.7	20.3	32.3	20.8	32.3	21.0	32.3	21.0	32.3	21.0
Capital Equipment	0.5		0.6		0.6		0.6		0.6		0.6		0.6	
Total Asst Secretary	74.4		27.7		32.3		33.0		33.0		33.0		33.0	
OTHER AGENCIES DATA SYSTEMS														
Total Operating	1.7	1.1	1.0	0.8	1.8	1.0	2.5	1.3	2.5	1.6	2.5	1.6	2.5	1.6

	FY 1985		FY 1986[a]		FY 1987[a]		FY 1988[a]		FY 1989		FY 1990		FY 1991	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
DEPARTMENT OF TRANSPORATION														
Total Operating	0.5	0.5	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
FED. EMERGENCY MANAGEMENT AGENCY														
Total Operating	1.9	4.3	2.7	3.1	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
Capital Equipment	0.1		0.0		0.0		0.0		0.0		0.0		0.0	
Total Asst Secretary	2.0		2.8		2.8		2.8		2.8		2.8		2.8	
NUCLEAR REGULATORY COMMISSION														
Total Operating	29.6	25.8	23.9	23.6	22.7	22.5	22.7	22.5	22.7	22.5	22.7	22.5	22.7	22.5
Capital Equipment	0.4		0.2		0.1		0.1		0.1		0.1		0.1	
Total Asst Secretary	30.0		24.1		22.9		22.9		22.9		22.9		22.9	
DEPARTMENT OF INTERIOR														
Total Operating	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DEPT. OF HEALTH & HUMAN SERVICES														
Total Operating	6.1	6.1	6.4	6.4	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8
Capital Equipment	0.1		0.0		0.0		0.0		0.0		0.0		0.0	
Total Asst Secretary	6.2		6.4		6.8		6.8		6.8		6.8		6.8	

Table A.3 (continued)

	FY 1985		FY 1986[a]		FY 1987[a]		FY 1988[a]		FY 1989		FY 1990		FY 1991	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
ENVIRONMENTAL PROTECTION AGENCY														
Total Operating	3.6	3.6	3.7	3.7	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
NATIONAL SCIENCE FOUNDATION														
Total Operating	1.4	1.4	1.7	1.7	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
TENNESSEE VALLEY AUTHORITY														
Total Operating	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
OTHER FEDERAL AGENCIES														
Total Operating	2.9	3.5	3.2	3.4	3.6	3.6	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
Capital Equipment	0.0		0.2		0.0		0.0		0.0		0.0		0.0	
Total Asst Secretary	2.9		3.4		3.6		3.4		3.4		3.4		3.4	
ELECTRIC POWER RESEARCH INSTITUTE														
Total Operating	2.3	2.4	2.5	2.6	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
OTHER NONFEDERAL AGENCIES														
Total Operating	4.1	4.7	4.3	4.4	3.4	3.4	3.5	3.5	3.6	3.6	3.8	3.8	4.0	4.0

	FY 1985		FY 1986[a]		FY 1987[a]		FY 1988[a]		FY 1989		FY 1990		FY 1991	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
Total Work for Others														
Total Operating	148.4	100.3	122.9	111.6	159.5	144.9	166.0	151.0	165.2	150.7	165.8	151.4	166.5	152.1
Capital Equipment	1.7		4.7		9.4		9.9		10.0		10.0		10.0	
Total WFO Programs	150.1		127.6		168.9		176.0		175.3		175.9		176.6	
General-Purpose Facilities	5.2		7.8											
General-Purpose Projects	9.4		15.7		23.9		21.2		18.7		16.2		16.2	
General-Purpose Equipment	3.8		12.3		19.6		11.8		11.8		10.5		10.5	
Proposed Program Construction	0.0		6.8		36.9		69.6		139.7		85.0		72.0	
Proposed MEL-GPF					11.9		25.3		32.7		51.7		46.2	
Total Laboratory Funding	498.3		510.3		653.5		691.8		758.9		720.8		702.1	

[a] Escalation factors from FY 1985 to FY 1986 and from FY 1986 to FY 1987 are both 7.0%. Figures for FY 1988 through FY 1991 are in constant FY 1987 dollars.

Table A.4. Personnel by Assistant Secretarial Level Office

(Full-time equivalents)

	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990	FY 1991
Assistant Secretary for Fossil Energy							
Technical Personnel	43.1	35.4	35.4	35.4	35.4	41.5	47.7
Other Direct Personnel	0.3	0.6	0.6	1.0	1.0	1.0	1.5
Total Direct Personnel	43.4	36.0	36.0	36.4	36.4	42.5	49.2
Assistant Secretary for Nuclear Energy							
Technical Personnel	220.8	217.1	239.7	233.0	220.9	232.8	239.4
Other Direct Personnel	30.8	24.4	27.6	27.8	27.4	31.2	30.2
Total Direct Personnel	251.6	241.5	267.3	260.8	248.3	264.0	269.6
Assistant Secretary for Conservation and Renewable Energy							
Technical Personnel	132.9	144.6	159.0	159.6	159.6	159.6	159.6
Other Direct Personnel	9.4	6.9	6.8	6.6	6.6	6.6	6.6
Total Direct Personnel	142.3	151.5	165.8	166.2	166.2	166.2	166.2
Office of Energy Research							
Technical Personnel	808.2	805.9	836.8	848.5	856.5	861.0	868.2
Other Direct Personnel	174.4	166.8	163.6	158.4	158.3	158.3	158.4
Total Direct Personnel	982.6	972.7	1000.4	1006.9	1014.8	1019.3	1026.6
Assistant Secretary for Defense Programs							
Technical Personnel	191.5	225.9	248.3	229.0	190.9	183.2	177.4
Other Direct Personnel	19.0	19.0	23.6	24.0	21.6	20.1	19.9
Total Direct Personnel	210.5	244.9	271.9	253.0	212.5	203.3	197.3
Assistant Secretary for Environment, Safety, and Health							
Technical Personnel	15.9	14.0	14.0	14.5	14.5	14.5	14.5
Other Direct Personnel	4.6	4.0	4.0	4.5	4.5	4.5	4.5
Total Direct Personnel	20.5	18.0	18.0	19.0	19.0	19.0	19.0

	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990	FY 1991
Federal Energy Regulatory Commission							
Technical Personnel	4.8	4.7	4.6	4.6	4.6	4.6	4.6
Other Direct Personnel	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Total Direct Personnel	4.9	4.7	4.6	4.6	4.6	4.6	4.6
Economic Regulatory Administration							
Technical Personnel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Direct Personnel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Direct Personnel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Energy Information Adminstration							
Technical Personnel	2.7	2.7	2.5	2.5	2.5	2.5	2.5
Other Direct Personnel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Direct Personnel	2.7	2.7	2.5	2.5	2.5	2.5	2.5
Office of Policy, Planning, and Analysis							
Technical Personnel	0.3	0.8	1.8	1.8	1.8	1.8	1.6
Other Direct Personnel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Direct Personnel	0.3	0.8	1.8	1.8	1.8	1.8	1.6
Office of Civilian Radioactive Waste Management							
Technical Personnel	13.6	17.9	17.1	16.8	16.7	16.7	16.7
Other Direct Personnel	2.3	1.8	2.1	2.1	1.8	1.8	1.8
Total Direct Personnel	15.9	19.7	19.2	18.9	18.5	18.5	18.5
Assistant Secretary for Management & Administration							
Technical Personnel	0.9	0.4	0.4	0.4	0.4	0.4	0.4
Other Direct Personnel	8.5	8.5	8.5	8.5	8.5	8.5	8.5
Total Direct Personnel	9.4	8.9	8.9	8.9	8.9	8.9	8.9

Table A.4 (continued)

	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990	FY 1991
Assistant Secretary for Congressional, Intergovernmental, & Public Affairs							
Technical Personnel	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Other Direct Personnel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Direct Personnel	0.1	0.0	0.0	0.0	0.0	0.0	0.0
DOE CONTRACTORS & OPERATIONS OFFICES							
Technical Personnel	102.7	65.1	50.4	48.5	48.5	48.5	48.5
Other Direct Personnel	13.7	4.1	3.1	1.2	1.2	1.2	1.2
Total Direct Personnel	116.4	69.2	53.5	49.7	49.7	49.7	49.7
Total DOE Programs							
Technical Personnel	1537.4	1534.5	1610.0	1594.6	1552.3	1567.1	1581.1
Other Direct Personnel	263.1	236.1	239.9	234.1	230.9	233.2	232.6
Total Direct Personnel	1800.6	1770.6	1849.9	1828.7	1783.2	1800.3	1813.7
DEPARTMENT OF DEFENSE							
Technical Personnel	136.8	289.3	478.2	508.7	499.8	499.8	499.8
Other Direct Personnel	22.2	41.7	65.1	68.8	67.7	70.0	70.0
Total Direct Personnel	159.0	331.0	543.3	577.5	567.5	569.8	569.8
DEPARTMENT OF DEFENSE DATA SYSTEMS							
Technical Personnel	56.4	70.7	93.7	98.4	100.2	100.2	100.2
Other Direct Personnel	42.7	52.8	40.2	42.5	42.7	42.7	42.7
Total Direct Personnel	99.1	123.5	133.9	140.9	142.9	142.9	142.9

	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990	FY 1991
OTHER AGENCIES DATA SYSTEMS							
Technical Personnel	2.7	4.9	5.8	8.3	11.1	11.1	11.1
Other Direct Personnel	0.3	0.6	0.7	0.9	1.0	1.0	1.0
Total Direct Personnel	3.0	5.5	6.5	9.2	12.1	12.1	12.1
DEPARTMENT OF TRANSPORATION							
Technical Personnel	2.8	2.7	2.9	2.9	2.9	2.9	2.9
Other Direct Personnel	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Total Direct Personnel	3.6	3.5	3.7	3.7	3.7	3.7	3.7
FEDERAL EMERGENCY MANAGEMENT AGENCY							
Technical Personnel	24.1	18.0	15.0	15.0	15.0	15.0	15.0
Other Direct Personnel	2.9	3.0	2.0	2.0	2.0	2.0	2.0
Total Direct Personnel	27.0	21.0	17.0	17.0	17.0	17.0	17.0
NUCLEAR REGULATORY COMMISSION							
Technical Personnel	154.8	125.1	119.0	109.5	109.5	109.5	109.5
Other Direct Personnel	20.3	15.8	14.3	12.5	12.5	12.5	12.5
Total Direct Personnel	175.1	140.9	133.3	122.0	122.0	122.0	122.0
DEPARTMENT OF INTERIOR							
Technical Personnel	0.1	0.1	0.1	0.0	0.0	0.0	0.0
Other Direct Personnel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Direct Personnel	0.1	0.1	0.1	0.0	0.0	0.0	0.0

Table A.4 (continued)

	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990	FY 1991
DEPARTMENT OF HEALTH & HUMAN SERVICES							
Technical Personnel	55.5	55.5	55.5	55.5	55.5	55.5	55.5
Other Direct Personnel	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Total Direct Personnel	56.0	56.0	56.0	56.0	56.0	56.0	56.0
ENVIRONMENTAL PROTECTION AGENCY							
Technical Personnel	27.5	27.5	27.5	27.5	27.5	27.5	27.5
Other Direct Personnel	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Total Direct Personnel	28.0	28.0	28.0	28.0	28.0	28.0	28.0
NATIONAL SCIENCE FOUNDATION							
Technical Personnel	7.5	9.0	9.0	9.0	9.0	9.0	9.0
Other Direct Personnel	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Total Direct Personnel	8.0	9.5	9.5	9.5	9.5	9.5	9.5
TENNESSEE VALLEY AUTHORITY							
Technical Personnel	2.2	1.6	1.6	1.9	1.9	1.9	1.9
Other Direct Personnel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Direct Personnel	2.2	1.6	1.6	1.9	1.9	1.9	1.9
OTHER FEDERAL AGENCIES							
Technical Personnel	16.8	15.9	16.5	15.9	15.9	15.9	15.9
Other Direct Personnel	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Total Direct Personnel	17.6	16.7	17.3	16.7	16.7	16.7	16.7

	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990	FY 1991
ELECTRIC POWER RESEARCH INSTITUTE							
Technical Personnel	11.9	11.4	11.0	11.0	11.0	11.0	11.0
Other Direct Personnel	0.8	0.8	0.8	1.0	1.0	1.0	1.0
Total Direct Personnel	12.7	12.2	11.8	12.0	12.0	12.0	12.0
OTHER NONFEDERAL AGENCIES							
Technical Personnel	18.9	18.1	15.6	15.8	17.3	18.3	19.8
Other Direct Personnel	2.8	0.8	0.8	0.3	0.3	0.3	0.3
Total Direct Personnel	21.7	18.9	16.4	16.1	17.6	18.6	20.1
Total Work for Others							
Technical Personnel	518.0	649.8	851.4	879.4	876.6	877.6	879.1
Other Direct Personnel	95.1	118.6	127.0	131.1	130.3	132.6	132.6
Total Direct Personnel	613.1	768.4	978.4	1010.5	1006.9	1010.2	1011.7
Total Direct							
Technical Personnel	2055.5	2184.3	2461.4	2474.0	2428.9	2444.7	2460.2
Other Direct Personnel	358.2	354.7	366.9	365.2	361.2	365.8	365.2
Total Direct Personnel	2413.7	2539.0	2828.3	2839.2	2790.1	2810.5	2825.4
Isotopes	49	48	48	48	48	48	48
Total Indirect Personnel	2532	2685	3018	3034	2980	2999	3017
Total Laboratory Personnel	4994	5272	5894	5921	5818	5858	5890

Table A.5. Resources by major program

($ in millions)

	FY 1985		FY 1986[a]		FY 1987[a]		FY 1988[a]		FY 1989		FY 1990		FY 1991	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
Assistant Secretary for Fossil Energy														
AA COAL														
Total Operating	7.1	7.2	8.3	7.9	7.7	7.9	7.7	7.9	7.7	7.9	8.5	8.7	9.3	9.5
Capital Equipment	.0		.0		.0		.0		.0		.0		.0	
Total Program	7.1		8.4		7.8		7.8		7.8		8.5		9.4	
Technical Personnel	41.4		35.4		35.4		35.4		35.4		41.5		47.7	
Other Direct Personnel	.3		.6		.6		1.0		1.0		1.0		1.5	
Total Direct Personnel	41.7		36.0		36.0		36.4		36.4		42.5		49.2	
AB GAS														
Total Operating	.0	.0	.0	.0	.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	
CH ALTERNATE FUELS PRODUCTION														
Total Operating	.0	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Technical Personnel	1.4		.0		.0		.0		.0		.0		.0	
Other Direct Personnel	.0		.0		.0		.0		.0		.0		.0	
Total Direct Personnel	1.4		.0		.0		.0		.0		.0		.0	
UE FUELS REGULATION														
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	

Assistant Secretary for Fossil Energy

Total Operating	7.1	7.4	8.3	7.9	7.7	7.9	7.7	7.9	7.7	7.9	8.5	8.7	9.3	9.5
Capital Equipment	.0		.0		.0		.0		.0		.0		.0	
Total Asst Secretary	7.1		8.4		7.8		7.8		7.8		8.5		9.4	
Technical Personnel	43.1		35.4		35.4		35.4		35.4		41.5		47.7	
Other Direct Personnel	.3		.6		.6		1.0		1.0		1.0		1.5	
Total Direct Personnel	43.4		36.0		36.0		36.4		36.4		42.5		49.2	

Assistant Secretary for Nuclear Energy

AE ADVANCED NUCLEAR SYSTEMS

Total Operating	2.0	1.7	3.5	3.4	5.1	4.6	5.3	5.1	5.0	4.8	5.0	4.8	5.0	4.8
Capital Equipment	.2		.4		.4		.4		.4		.4		.4	
Total Program	2.2		3.9		5.5		5.7		5.4		5.4		5.4	
Technical Personnel	10.3		16.1		22.4		24.4		22.5		22.5		22.5	
Other Direct Personnel	1.1		2.8		3.4		3.7		3.5		3.5		3.5	
Total Direct Personnel	11.4		18.9		25.8		28.1		26.0		26.0		26.0	

AF BREEDER REACTOR SYSTEMS

Total Operating	10.2	9.8	7.4	7.0	6.4	6.0	5.3	5.0	5.3	5.0	5.3	5.0	5.3	5.0
Technical Personnel	58.6		40.0		37.0		31.0		31.0		31.0		31.0	
Other Direct Personnel	4.3		2.0		2.0		.0		.0		.0		.0	
Total Direct Personnel	62.9		42.0		39.0		31.0		31.0		31.0		31.0	

AG CONVERTER REACTOR SYSTEMS

Total Operating	4.1	4.2	3.9	3.7	5.8	5.8	9.0	8.5	10.0	9.5	11.5	10.5	11.0	10.5
Capital Equipment	.5		.0		.6		.7		1.0		1.0		.8	
Total Program	4.6		3.9		6.5		9.7		11.0		12.5		11.8	
Technical Personnel	25.1		24.7		44.8		63.5		63.5		68.5		66.5	
Other Direct Personnel	.8		.9		3.7		5.0		5.0		8.0		7.0	
Total Direct Personnel	25.9		25.6		48.5		68.5		68.5		76.5		73.5	

Table A.5 (continued)

	FY 1985		FY 1986[a]		FY 1987[a]		FY 1988[a]		FY 1989		FY 1990		FY 1991	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
AH REMEDIAL ACTION PROGRAMS														
Total Operating	6.3	6.3	8.6	8.6	8.7	8.7	3.9	3.9	2.8	2.8	3.4	3.4	4.3	4.3
Capital Equipment	.3		.2		.1		.0		.0		.0		.0	
Total Program	6.6		8.8		8.8		3.9		2.8		3.4		4.3	
Technical Personnel	44.2		53.0		52.4		33.4		23.2		30.1		38.7	
Other Direct Personnel	2.6		2.7		2.5		3.1		2.9		3.7		3.7	
Total Direct Personnel	46.8		55.7		54.9		36.5		26.1		33.8		42.4	
AP COMMERCIAL NUCLEAR WASTE MANAGEMENT														
Total Operating	.2	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Capital Equipment	.1		.0		.0		.0		.0		.0		.0	
Total Program	.3		.0		.0		.0		.0		.0		.0	
Technical Personnel	1.1		.2		.2		.2		.2		.2		.2	
Other Direct Personnel	.0		.0		.0		.0		.0		.0		.0	
Total Direct Personnel	1.1		.2		.2		.2		.2		.2		.2	
AS NUCLEAR FUEL CYCLE														
Total Operating	17.4	17.4	13.1	13.1	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Capital Equipment	.8		.0		.0		.0		.0		.0		.0	
Total Program	18.2		13.1		15.0		15.0		15.0		15.0		15.0	
Technical Personnel	78.2		80.5		80.5		80.5		80.5		80.5		80.5	
Other Direct Personnel	22.0		16.0		16.0		16.0		16.0		16.0		16.0	
Total Direct Personnel	100.2		96.5		96.5		96.5		96.5		96.5		96.5	
CD URANIUM ENRICHMENT														
Total Operating	.7	.7	.5	.5	.5	.5	.0	.0	.0	.0	.0	.0	.0	.0
Technical Personnel	3.3		2.6		2.4		.0		.0		.0		.0	
Other Direct Personnel	.0		.0		.0		.0		.0		.0		.0	
Total Direct Personnel	3.3		2.6		2.4		.0		.0		.0		.0	

Assistant Secretary for Nuclear Energy

Total Operating	41.0	40.4	37.0	36.3	41.5	40.6	38.6	37.6	38.1	37.1	40.3	38.8	40.6	39.6
Capital Equipment	1.8		.6		1.1		1.1		1.4		1.4		1.2	
Total Asst Secretary	42.8		37.6		42.7		39.7		39.6		41.7		41.9	
Technical Personnel	220.8		217.1		239.7		233.0		220.9		232.8		239.4	
Other Direct Personnel	30.8		24.4		27.6		27.8		27.4		31.2		30.2	
Total Direct Personnel	251.6		241.5		267.3		260.8		248.3		264.0		269.6	

Assistant Secretary for Conservation and Renewable Energy

AK ELECTRIC ENERGY SYSTEMS

Total Operating	7.7	7.6	4.0	5.2	6.4	6.8	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Capital Equipment	.1		.1		.1		.1		.1		.1		.1	
Total Program	7.8		4.2		6.5		7.6		7.6		7.6		7.6	
Technical Personnel	19.5		17.5		18.5		22.0		22.0		22.0		22.0	
Other Direct Personnel	1.5		1.5		1.5		1.5		1.5		1.5		1.5	
Total Direct Personnel	21.0		19.0		20.0		23.5		23.5		23.5		23.5	

AL ENERGY STORAGE SYSTEMS

Total Operating	1.1	1.5	1.0	1.0	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Technical Personnel	4.1		4.2		4.2		4.2		4.2		4.2		4.2	
Other Direct Personnel	.3		.1		.1		.1		.1		.1		.1	
Total Direct Personnel	4.4		4.3		4.3		4.3		4.3		4.3		4.3	

AM GEOTHERMAL

Total Operating	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
Technical Personnel	.5		.5		.5		.5		.5		.5		.5	
Other Direct Personnel	.0		.0		.0		.0		.0		.0		.0	
Total Direct Personnel	.5		.5		.5		.5		.5		.5		.5	

CC GEOTHERMAL

Total Operating	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
Technical Personnel	.3		.4		.4		.4		.4		.4		.4	
Other Direct Personnel	.0		.0		.0		.0		.0		.0		.0	
Total Direct Personnel	.3		.4		.4		.4		.4		.4		.4	

Table A.5 (continued)

	FY 1985		FY 1986[a]		FY 1987[a]		FY 1988[a]		FY 1989		FY 1990		FY 1991	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
CE HYDROPOWER														
Total Operating	.0	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2
Technical Personnel	.2		.9		1.0		1.0		1.0		1.0		1.0	
Other Direct Personnel	.0		.0		.0		.0		.0		.0		.0	
Total Direct Personnel	.2		.9		1.0		1.0		1.0		1.0		1.0	
EB SOLAR ENERGY														
Total Operating	4.4	5.5	5.8	5.9	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3
Capital Equipment	.1		.3		.3		.3		.3		.3		.3	
Total Program	4.5		6.1		6.6		6.6		6.6		6.6		6.6	
Technical Personnel	15.2		16.5		17.0		17.0		17.0		17.0		17.0	
Other Direct Personnel	1.2		1.3		1.3		1.1		1.1		1.1		1.1	
Total Direct Personnel	16.4		17.8		18.3		18.1		18.1		18.1		18.1	
EC BUILDINGS AND COMMUNITY SYSTEMS														
Total Operating	11.2	12.9	12.0	11.9	12.2	12.2	13.0	12.8	13.0	13.0	13.0	13.0	13.0	13.0
Capital Equipment	1.2		1.9		1.0		.3		.3		.3		.3	
Total Program	12.5		13.9		13.1		13.3		13.3		13.3		13.3	
Technical Personnel	44.0		42.8		41.0		39.9		39.9		39.9		39.9	
Other Direct Personnel	5.7		3.3		3.2		3.2		3.2		3.2		3.2	
Total Direct Personnel	49.7		46.1		44.2		43.1		43.1		43.1		43.1	
ED INDUSTRIAL														
Total Operating	1.5	1.3	1.7	1.7	1.8	2.0	1.8	2.0	1.8	2.0	1.8	2.0	1.8	2.0
Capital Equipment	.1		.0		.0		.0		.0		.0		.0	
Total Program	1.5		1.8		1.8		1.8		1.8		1.8		1.8	
Technical Personnel	7.2		7.5		7.7		7.7		7.7		7.7		7.7	
Other Direct Personnel	.5		.5		.5		.5		.5		.5		.5	
Total Direct Personnel	7.7		8.0		8.2		8.2		8.2		8.2		8.2	

EE TRANSPORTATION																
Total Operating	7.6	7.5	11.2	10.2	17.7	12.5	18.6	13.6	15.6	15.6	13.6	13.6	11.6	11.6		
Capital Equipment	1.9		1.5		.8		.5		.2		.2		.2			
Construction	6.5		2.7		.0		.0		.0		.0		.0			
Total Program	15.9		15.4		18.4		19.1		15.9		13.9		11.9			
Technical Personnel	21.8		27.2		36.0		36.0		36.0		36.0		36.0			
Other Direct Personnel	.1		.1		.1		.1		.1		.1		.1			
Total Direct Personnel	21.9		27.3		36.1		36.1		36.1		36.1		36.1			
EF STATE/LOCAL PROGRAMS																
Total Operating	-.2	.2	.3	.3	.2	.3	.0	.0	.0	.0	.0	.0	.0	.0		
Technical Personnel	.8		1.5		1.8		.0		.0		.0		.0			
Other Direct Personnel	.0		.0		.0		.0		.0		.0		.0			
Total Direct Personnel	.8		1.5		1.8		.0		.0		.0		.0			
EG MULTI-SECTOR																
Total Operating	4.7	4.6	7.9	7.4	12.6	11.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5		
Capital Equipment	.4		.5		.8		.5		.5		.5		.5			
Total Program	5.1		8.4		13.4		13.0		13.0		13.0		13.0			
Technical Personnel	19.3		25.6		30.9		30.9		30.9		30.9		30.9			
Other Direct Personnel	.1		.1		.1		.1		.1		.1		.1			
Total Direct Personnel	19.4		25.7		31.0		31.0		31.0		31.0		31.0			
Assistant Secretary for Conservation and Renewable Energy																
Total Operating	38.1	41.3	44.2	43.9	59.0	53.5	61.5	56.6	58.6	58.8	56.6	56.8	54.6	54.8		
Capital Equipment	3.9		4.3		3.0		1.8		1.5		1.5		1.5			
Construction	6.5		2.7		.0		.0		.0		.0		.0			
Total Asst Secretary	48.4		51.2		61.9		63.3		60.1		58.1		56.1			
Technical Personnel	132.9		144.6		159.0		159.6		159.5		159.6		159.6			
Other Direct Personnel	9.4		6.9		6.8		6.6		6.6		6.6		6.6			
Total Direct Personnel	142.3		151.5		165.8		166.2		166.1		166.2		166.2			

Table A.5 (continued)

	FY 1985		FY 1986[a]		FY 1987[a]		FY 1988[a]		FY 1989		FY 1990		FY 1991	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
Office of Energy Research														
AT MAGNETIC FUSION														
Total Operating	53.9	56.6	52.8	55.1	59.7	53.2	51.4	51.4	51.4	51.4	51.4	51.4	51.4	51.4
Capital Equipment	4.0		4.6		6.7		6.7		6.7		6.7		6.7	
Total Program	57.9		57.5		66.3		58.1		58.1		58.1		58.1	
Technical Personnel	155.1		153.3		156.7		154.7		154.7		154.7		154.7	
Other Direct Personnel	137.4		127.2		123.2		114.1		114.1		114.1		114.1	
Total Direct Personnel	292.5		280.5		279.9		268.8		268.8		268.8		268.8	
HA ENVIRONMENTAL RESEARCH & DEVELOPMENT														
Total Operating	26.1	29.8	27.5	27.5	29.2	29.2	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
Capital Equipment	1.5		1.3		1.5		1.5		1.5		1.5		1.5	
Total Program	27.6		28.8		30.7		31.5		31.5		31.5		31.5	
Proposed Construction	.0		.0		13.7		14.9		4.7		.0		.0	
Technical Personnel	172.0		160.0		160.0		160.0		160.0		160.0		160.0	
Other Direct Personnel	8.0		6.0		6.0		6.0		6.0		6.0		6.0	
Total Direct Personnel	180.0		166.0		166.0		166.0		166.0		166.0		166.0	
KA HIGH ENERGY PHYSICS														
Total Operating	.6	.4	.5	.4	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5
Technical Personnel	3.0		3.0		3.0		3.0		3.0		3.0		3.0	
Other Direct Personnel	1.0		1.0		1.0		1.0		1.0		1.0		1.0	
Total Direct Personnel	4.0		4.0		4.0		4.0		4.0		4.0		4.0	

KB NUCLEAR PHYSICS

Total Operating	11.8	10.1	10.3	10.1	10.9	10.8	10.9	10.9	11.1	11.1	11.3	11.3	11.5	11.5
Capital Equipment	1.1		1.2		1.2		1.3		1.3		1.3		1.3	
Construction	.0		.5		.0		.0		.0		.0		.0	
Total Program	13.0		12.0		12.2		12.2		12.4		12.6		12.8	
Proposed Construction	.0		.0		.0		.0		12.0		15.0		12.0	
Technical Personnel	75.6		74.4		74.4		74.7		76.3		77.8		79.1	
Other Direct Personnel	2.6		2.3		2.3		2.3		2.2		2.2		2.3	
Total Direct Personnel	78.2		76.7		76.7		77.0		78.5		80.0		81.4	

KC BASIC ENERGY SCIENCES

Total Operating	64.1	52.2	59.8	54.1	61.1	59.9	61.8	61.8	62.6	62.6	63.1	63.1	63.8	63.8
Capital Equipment	6.1		6.7		6.7		6.8		6.8		7.1		7.4	
Construction	.3		.0		.0		.0		.0		.0		.0	
Total Program	70.4		66.6		67.8		68.6		69.4		70.1		71.2	
Proposed Construction	.0		2.8		8.5		20.2		18.0		45.0		60.0	
Technical Personnel	378.8		372.7		391.0		402.4		408.8		411.8		417.7	
Other Direct Personnel	8.9		14.1		15.1		15.0		15.0		15.0		15.0	
Total Direct Personnel	387.7		386.8		406.1		417.4		423.8		426.8		432.7	

KD ENERGY RESEARCH ANALYSIS

Total Operating	.5	1.1	1.1	.6	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Technical Personnel	5.5		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	5.5		3.0		3.0		3.0		3.0		3.0		3.0	

KE UNIVERSITY RESEARCH SUPPORT

Total Operating	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3
Technical Personnel	.7		.7		.7		.7		.7		.7		.7	
Other Direct Personnel	.0		.0		.0		.0		.0		.0		.0	
Total Direct Personnel	.7		.7		.7		.7		.7		.7		.7	

Table A.5 (continued)

	FY 1985		FY 1986[a]		FY 1987[a]		FY 1988[a]		FY 1989		FY 1990		FY 1991	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
KG MULTI-PROGRAM LABORATORY FACILITIES SUPPORT														
Total Operating	5.4	5.4	18.2	12.9	35.3	30.0	46.3	45.0	46.3	45.0	46.3	45.0	46.3	45.0
Capital Equipment	.0		1.0		2.6		1.3		1.3		1.3		1.3	
Total Program	5.4		19.2		37.9		47.6		47.6		47.6		47.6	
Proposed Construction	.0		3.0		15.0		.0		40.0		.0		.0	
Technical Personnel	17.5		38.8		48.0		50.0		50.0		50.0		50.0	
Other Direct Personnel	16.5		16.2		16.0		20.0		20.0		20.0		20.0	
Total Direct Personnel	34.0		55.0		64.0		70.0		70.0		70.0		70.0	
Office of Energy Research														
Total Operating	162.6	156.0	170.5	161.0	198.2	185.0	202.3	201.0	203.3	202.0	204.0	202.7	204.9	203.6
Capital Equipment	12.7		14.9		18.7		17.5		17.5		17.9		18.2	
Construction	.3		.5		.0		.0		.0		.0		.0	
Total Asst Secretary	175.6		185.9		216.9		219.8		220.9		221.8		223.1	
Proposed Construction	.0		5.8		37.3		35.1		74.7		60.0		72.0	
Technical Personnel	808.2		805.9		836.8		848.5		856.5		861.0		868.2	
Other Direct Personnel	174.4		166.8		163.6		158.4		158.3		158.3		158.4	
Total Direct Personnel	982.6		972.7		1000.4		1006.9		1014.8		1019.3		1026.6	
Assistant Secretary for Defense Programs														
AR DEFENSE WASTE & BY-PRODUCTS MANAGEMENT														
Total Operating	22.6	21.8	27.5	27.1	33.7	31.4	30.3	30.3	28.2	28.2	27.5	27.5	26.5	26.5
Capital Equipment	1.9		1.7		2.7		1.7		1.7		1.7		1.6	
Total Program	24.5		29.1		36.4		31.9		29.9		29.2		28.1	
Proposed Construction	.0		1.0		.0		34.5		65.0		25.0		.0	
Technical Personnel	141.2		169.7		190.2		181.7		168.6		163.1		157.3	
Other Direct Personnel	14.3		16.5		18.3		18.3		17.4		16.9		16.7	
Total Direct Personnel	155.5		186.2		208.5		200.0		186.0		180.0		174.0	

GC VERIFICATION & CONTROL TECHNOLOGY

Total Operating	.3	.3	.4	.3	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4
Capital Equipment	.0		.2		.4		.4		.4		.4		.4	
Total Program	.3		.6		.7		.7		.7		.7		.7	
Technical Personnel	2.3		2.3		2.5		2.5		2.5		2.5		2.5	
Other Direct Personnel	.0		.0		.0		.0		.0		.0		.0	
Total Direct Personnel	2.3		2.3		2.5		2.5		2.5		2.5		2.5	

GD NUCLEAR SAFEGUARDS AND SECURITY

Total Operating	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4	.5	.5
Capital Equipment	.1		.0		.0		.0		.0		.0		.0	
Total Program	.5		.4		.4		.5		.5		.5		.5	
Technical Personnel	2.8		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	2.8		3.0		3.0		3.0		3.0		3.0		3.0	

GE MATERIALS PRODUCTION

Total Operating	6.0	5.4	6.3	6.0	6.6	6.8	5.5	5.5	2.7	2.7	2.3	2.3	2.3	2.3
Capital Equipment	.0		.1		.1		.1		.1		.1		.1	
Total Program	6.0		6.3		6.6		5.5		2.7		2.3		2.3	
Technical Personnel	45.2		50.9		52.6		41.8		16.8		14.6		14.6	
Other Direct Personnel	4.7		2.5		5.3		5.7		4.2		3.2		3.2	
Total Direct Personnel	49.9		53.4		57.9		47.5		21.0		17.8		17.8	

Assistant Secretary for Defense Programs

Total Operating	29.3	27.8	34.6	33.8	41.1	39.0	36.5	36.5	31.6	31.6	30.6	30.6	29.6	29.6
Capital Equipment	2.0		2.0		3.1		2.1		2.2		2.2		2.0	
Total Asst Secretary	31.3		36.5		44.2		38.6		33.8		32.7		31.6	
Proposed Construction	.0		1.0		.0		34.5		65.0		25.0		.0	
Technical Personnel	191.5		225.9		248.3		229.0		190.9		183.2		177.4	
Other Direct Personnel	19.0		19.0		23.6		24.0		21.6		20.1		19.9	
Total Direct Personnel	210.5		244.9		271.9		253.0		212.5		203.3		197.3	

Table A.5 (continued)

	FY 1985		FY 1986[a]		FY 1987[a]		FY 1988[a]		FY 1989		FY 1990		FY 1991	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
Assistant Secretary for Environment, Safety, and Health														
HA ENVIRONMENTAL RESEARCH & DEVELOPMENT														
Total Operating	2.4	3.5	2.9	3.0	3.1	3.1	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
Technical Personnel	15.5		14.0		14.0		14.5		14.5		14.5		14.5	
Other Direct Personnel	4.5		4.0		4.0		4.5		4.5		4.5		4.5	
Total Direct Personnel	20.0		18.0		18.0		19.0		19.0		19.0		19.0	
UB UTILITY PROGRAMS & REGULATORY INTERVENTION														
Total Operating	.0	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Technical Personnel	.4		.0		.0		.0		.0		.0		.0	
Other Direct Personnel	.1		.0		.0		.0		.0		.0		.0	
Total Direct Personnel	.5		.0		.0		.0		.0		.0		.0	
Assistant Secretary for Environment, Safety, and Health														
Total Operating	2.4	3.6	2.9	3.0	3.1	3.1	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
Technical Personnel	15.9		14.0		14.0		14.5		14.5		14.5		14.5	
Other Direct Personnel	4.6		4.0		4.0		4.5		4.5		4.5		4.5	
Total Direct Personnel	20.5		18.0		18.0		19.0		19.0		19.0		19.0	
Federal Energy Regulatory Commission														
VP OTHER EXPENSES														
Total Operating	.8	.8	.8	.8	.8	.8	.8	.8	.8	.8	.8	.8	.8	.8
Technical Personnel	4.8		4.7		4.6		4.6		4.6		4.6		4.6	
Other Direct Personnel	.1		.0		.0		.0		.0		.0		.0	
Total Direct Personnel	4.9		4.7		4.6		4.6		4.6		4.6		4.6	

Federal Energy Regulatory Commission

Total Operating	.8	.8	.8	.8	.8	.8	.8	.8	.8	.8	.8	.8	.8	.8	.8	.8	.8	.8
Technical Personnel	4.8		4.7		4.6		4.6		4.6		4.6		4.6		4.6		4.6	
Other Direct Personnel	.1		.0		.0		.0		.0		.0		.0		.0		.0	
Total Direct Personnel	4.9		4.7		4.6		4.6		4.6		4.6		4.6		4.6		4.6	

Economic Regulatory Administration

UC COMPLIANCE

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

Economic Regulatory Administration

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

Energy Information Administration

TA COLLECTION, PRODUCTION & ANALYSIS

Total Operating	2.1	1.4	1.0	2.2	1.0	1.2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Technical Personnel	2.7		2.7		2.5		2.5		2.5		2.5		2.5		2.5		2.5	
Other Direct Personnel	.0		.0		.0		.0		.0		.0		.0		.0		.0	
Total Direct Personnel	2.7		2.7		2.5		2.5		2.5		2.5		2.5		2.5		2.5	

TB PROGRAM SERVICES

Total Operating	.2	.2	.0	.3	.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	
Other Direct Personnel	.0		.0		.0		.0		.0		.0		.0		.0		.0	
Total Direct Personnel	.0		.0		.0		.0		.0		.0		.0		.0		.0	

Table A.5 (continued)

	FY 1985		FY 1986[a]		FY 1987[a]		FY 1988[a]		FY 1989		FY 1990		FY 1991	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
Energy Information Adminstration														
Total Operating	2.3	1.6	1.0	2.5	1.0	1.2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Technical Personnel	2.7		2.7		2.5		2.5		2.5		2.5		2.5	
Other Direct Personnel	.0		.0		.0		.0		.0		.0		.0	
Total Direct Personnel	2.7		2.7		2.5		2.5		2.5		2.5		2.5	
Office of Policy, Planning, and Analysis														
PE POLICY ANALYSIS & SYSTEM STUDIES														
Total Operating	.2	.3	.1	.1	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2
Technical Personnel	.3		.8		1.8		1.8		1.8		1.8		1.6	
Other Direct Personnel	.0		.0		.0		.0		.0		.0		.0	
Total Direct Personnel	.3		.8		1.8		1.8		1.8		1.8		1.6	
Office of Policy, Planning, and Analysis														
Total Operating	.2	.3	.1	.1	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2
Technical Personnel	.3		.8		1.8		1.8		1.8		1.8		1.6	
Other Direct Personnel	.0		.0		.0		.0		.0		.0		.0	
Total Direct Personnel	.3		.8		1.8		1.8		1.8		1.8		1.6	
Office of Civilian Radioactive Waste Management														
DB NUCLEAR WASTE FUND														
Total Operating	3.6	3.3	4.4	4.1	4.1	4.1	4.1	4.1	4.0	4.0	3.9	3.9	3.9	3.9
Capital Equipment	.0		.1		.0		.0		.0		.0		.0	
Total Program	3.6		4.4		4.2		4.1		4.0		3.9		3.9	
Technical Personnel	13.4		17.9		17.1		16.8		16.7		16.7		16.7	
Other Direct Personnel	2.3		1.8		2.1		2.1		1.8		1.8		1.8	
Total Direct Personnel	15.7		19.7		19.2		18.9		18.5		18.5		18.5	

DC CIVILIAN RADIOACTIVE WASTE

Total Operating	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Technical Personnel	.2		.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	.2		.0		.0		.0		.0		.0		.0		.0		.0		.0	

Office of Civilian Radioactive Waste Management

Total Operating	3.6	3.3	4.4	4.1	4.1	4.1	4.1	4.1	4.0	4.0	3.9	3.9	3.9	3.9						
Capital Equipment	.0		.1		.0		.0		.0		.0		.0							
Total Asst Secretary	3.6		4.4		4.2		4.1		4.0		3.9		3.9							
Technical Personnel	13.6		17.9		17.1		16.8		16.7		16.7		16.7							
Other Direct Personnel	2.3		1.8		2.1		2.1		1.8		1.8		1.8							
Total Direct Personnel	15.9		19.7		19.2		18.9		18.5		18.5		18.5							

Assistant Secretary for Management and Administration

LA TECHNICAL INFORMATION MANAGEMENT

Total Operating	1.1	1.1	1.2	1.2	1.3	1.2	1.3	.9	1.3	.9	1.3	.9	1.3	.9						
Capital Equipment	.1		.1		.1		.1		.1		.1		.1							
Total Program	1.2		1.3		1.4		1.4		1.4		1.4		1.4							
Technical Personnel	.4		.4		.4		.4		.4		.4		.4							
Other Direct Personnel	8.5		8.5		8.5		8.5		8.5		8.5		8.5							
Total Direct Personnel	8.9		8.9		8.9		8.9		8.9		8.9		8.9							

WB IN-HOUSE ENERGY MANAGEMENT

Total Operating	.1	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Technical Personnel	.5		.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	.5		.0		.0		.0		.0		.0		.0		.0		.0		.0	

Assistant Secretary for Management & Administration

Total Operating	1.2	1.2	1.2	1.2	1.3	1.2	1.3	.9	1.3	.9	1.3	.9	1.3	.9						
Capital Equipment	.1		.1		.1		.1		.1		.1		.1							
Total Asst Secretary	1.3		1.3		1.4		1.4		1.4		1.4		1.4							
Technical Personnel	.9		.4		.4		.4		.4		.4		.4							
Other Direct Personnel	8.5		8.5		8.5		8.5		8.5		8.5		8.5							
Total Direct Personnel	9.4		8.9		8.9		8.9		8.9		8.9		8.9							

Table A.5 (continued)

	FY 1985		FY 1986[a]		FY 1987[a]		FY 1988[a]		FY 1989		FY 1990		FY 1991	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
Assistant Secretary for Congressional, Intergovernmental, and Public Affairs														
LD CONSUMER AFFAIRS														
Total Operating	.0	.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 Congressional, Intergovernmental, & Public Affairs														
Total Operating	.0	.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	
DOE CONTRACTORS & OPERATIONS OFFICE														
Total Operating	13.3	14.5	9.7	10.0	8.1	8.2	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Capital Equipment	.4		.3		.1		.0		.1		.1		.1	
Total Program	13.7		10.0		8.2		8.0		8.1		8.1		8.1	
Technical Personnel	102.7		65.1		50.4		48.5		48.5		48.5		48.5	
Other Direct Personnel	13.7		4.1		3.1		1.2		1.2		1.2		1.2	
Total Direct Personnel	116.4		69.2		53.5		49.7		49.7		49.7		49.7	
Total DOE Programs														
Total Operating	302.0	298.2	314.6	304.6	366.1	344.9	365.1	357.8	357.8	355.7	358.3	355.6	357.4	355.2
Capital Equipment	20.8		22.3		26.3		22.7		22.9		23.2		23.2	
Construction	6.8		3.2		.0		.0		.0		.0		.0	
Total Program	329.6		340.1		392.3		387.9		380.7		381.5		380.6	
Proposed Construction	.0		6.8		37.3		69.6		139.7		85.0		72.0	
Technical Personnel	1537.4		1534.5		1610.0		1594.6		1552.3		1567.1		1581.1	
Other Direct Personnel	263.1		236.1		239.9		234.1		230.9		233.2		232.6	
Total Direct Personnel	1800.6		1770.6		1849.9		1828.7		1783.2		1800.3		1813.7	

Work for Others

DEPARTMENT OF DEFENSE

Total Operating	20.1	16.0	45.6	43.4	77.6	75.6	82.9	80.9	82.0	79.9	82.4	80.4	82.9	80.9
Capital Equipment	.5		3.7		8.6		9.2		9.3		9.3		9.3	
Total Program	20.6		49.3		86.3		92.1		91.3		91.7		92.2	
Technical Personnel	136.8		289.3		478.2		508.7		499.8		499.8		499.8	
Other Direct Personnel	22.2		41.7		65.1		68.8		67.7		70.0		70.0	
Total Direct Personnel	159.0		331.0		543.3		577.5		567.5		569.8		569.8	

DEPARTMENT OF DEFENSE DATA SYSTEMS

Total Operating	73.9	30.6	27.1	17.8	31.7	20.3	32.4	20.8	32.4	21.0	32.4	21.0	32.4	21.0
Capital Equipment	.5		.6		.6		.6		.6		.6		.6	
Total Program	74.4		27.7		32.3		33.0		33.0		33.0		33.0	
Technical Personnel	56.4		70.7		93.7		98.4		100.2		100.2		100.2	
Other Direct Personnel	42.7		52.8		40.2		42.5		42.7		42.7		42.7	
Total Direct Personnel	99.1		123.5		133.9		140.9		142.9		142.9		142.9	

OTHER AGENCIES DATA SYSTEMS

Total Operating	1.7	1.1	1.0	.8	1.8	1.0	2.5	1.3	2.5	1.6	2.5	1.6	2.5	1.6
Technical Personnel	2.7		4.9		5.8		8.3		11.1		11.1		11.1	
Other Direct Personnel	.3		.6		.7		.9		1.0		1.0		1.0	
Total Direct Personnel	3.0		5.5		6.5		9.2		12.1		12.1		12.1	

DEPARTMENT OF TRANSPORATION

Total Operating	.5	.5	.4	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5
Technical Personnel	2.8		2.7		2.9		2.9		2.9		2.9		2.9	
Other Direct Personnel	.8		.8		.8		.8		.8		.8		.8	
Total Direct Personnel	3.6		3.5		3.7		3.7		3.7		3.7		3.7	

FEDERAL EMERGENCY MANAGEMENT AGENCY

Total Operating	1.9	4.3	2.7	3.1	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
Capital Equipment	.1		.0		.0		.0		.0		.0		.0	
Total Program	2.0		2.8		2.8		2.8		2.8		2.8		2.8	
Technical Personnel	24.1		18.0		15.0		15.0		15.0		15.0		15.0	
Other Direct Personnel	2.9		3.0		2.0		2.0		2.0		2.0		2.0	
Total Direct Personnel	27.0		21.0		17.0		17.0		17.0		17.0		17.0	

Table A.5 (continued)

	FY 1985		FY 1986[a]		FY 1987[a]		FY 1988[a]		FY 1989		FY 1990		FY 1991	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
NUCLEAR REGULATORY COMMISSION														
Total Operating	29.6	25.8	23.9	23.6	22.7	22.5	22.7	22.5	22.7	22.5	22.7	22.5	22.7	22.5
Capital Equipment	.4		.2		.1		.1		.1		.1		.1	
Total Program	30.0		24.1		22.9		22.9		22.9		22.9		22.9	
Technical Personnel	154.8		125.1		119.0		109.5		109.5		109.5		109.5	
Other Direct Personnel	20.3		15.8		14.3		12.5		12.5		12.5		12.5	
Total Direct Personnel	175.1		140.9		133.3		122.0		122.0		122.0		122.0	
DEPARTMENT OF INTERIOR														
Total Operating	.1	.1	.1	.1	.1	.1	.0	.0	.0	.0	.0	.0	.0	.0
Technical Personnel	.1		.1		.1		.0		.0		.0		.0	
Other Direct Personnel	.0		.0		.0		.0		.0		.0		.0	
Total Direct Personnel	.1		.1		.1		.0		.0		.0		.0	
DEPARTMENT OF HEALTH & HUMAN SERVICES														
Total Operating	6.1	6.1	6.4	6.4	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8
Capital Equipment	.1		.0		.0		.0		.0		.0		.0	
Total Program	6.2		6.4		6.8		6.8		6.8		6.8		6.8	
Technical Personnel	55.5		55.5		55.5		55.5		55.5		55.5		55.5	
Other Direct Personnel	.5		.5		.5		.5		.5		.5		.5	
Total Direct Personnel	56.0		56.0		56.0		56.0		56.0		56.0		56.0	
ENVIRONMENTAL PROTECTION AGENCY														
Total Operating	3.6	3.6	3.7	3.7	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
Technical Personnel	27.5		27.5		27.5		27.5		27.5		27.5		27.5	
Other Direct Personnel	.5		.5		.5		.5		.5		.5		.5	
Total Direct Personnel	28.0		28.0		28.0		28.0		28.0		28.0		28.0	

NATIONAL SCIENCE FOUNDATION

Total Operating	1.4	1.4	1.7	1.7	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Technical Personnel	7.5		9.0		9.0		9.0		9.0		9.0		9.0		9.0	
Other Direct Personnel	.5		.5		.5		.5		.5		.5		.5		.5	
Total Direct Personnel	8.0		9.5		9.5		9.5		9.5		9.5		9.5		9.5	

TENNESSEE VALLEY AUTHORITY

Total Operating	.3	.3	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2
Technical Personnel	2.2		1.6		1.6		1.9		1.9		1.9		1.9		1.9	
Other Direct Personnel	.0		.0		.0		.0		.0		.0		.0		.0	
Total Direct Personnel	2.2		1.6		1.6		1.9		1.9		1.9		1.9		1.9	

OTHER FEDERAL AGENCIES

Total Operating	2.9	3.5	3.2	3.4	3.6	3.6	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Capital Equipment	.0		.2		.0		.0		.0		.0		.0		.0	
Total Program	2.9		3.4		3.6		3.5		3.5		3.5		3.5			
Technical Personnel	16.8		15.9		16.5		15.9		15.9		15.9		15.9			
Other Direct Personnel	.8		.8		.8		.8		.8		.8		.8			
Total Direct Personnel	17.6		16.7		17.3		16.7		16.7		16.7		16.7			

ELECTRIC POWER RESEARCH INSTITUTE

Total Operating	2.4	2.4	2.5	2.6	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Technical Personnel	11.9		11.4		11.0		11.0		11.0		11.0		11.0			
Other Direct Personnel	.8		.8		.8		1.0		1.0		1.0		1.0			
Total Direct Personnel	12.7		12.2		11.8		12.0		12.0		12.0		12.0			

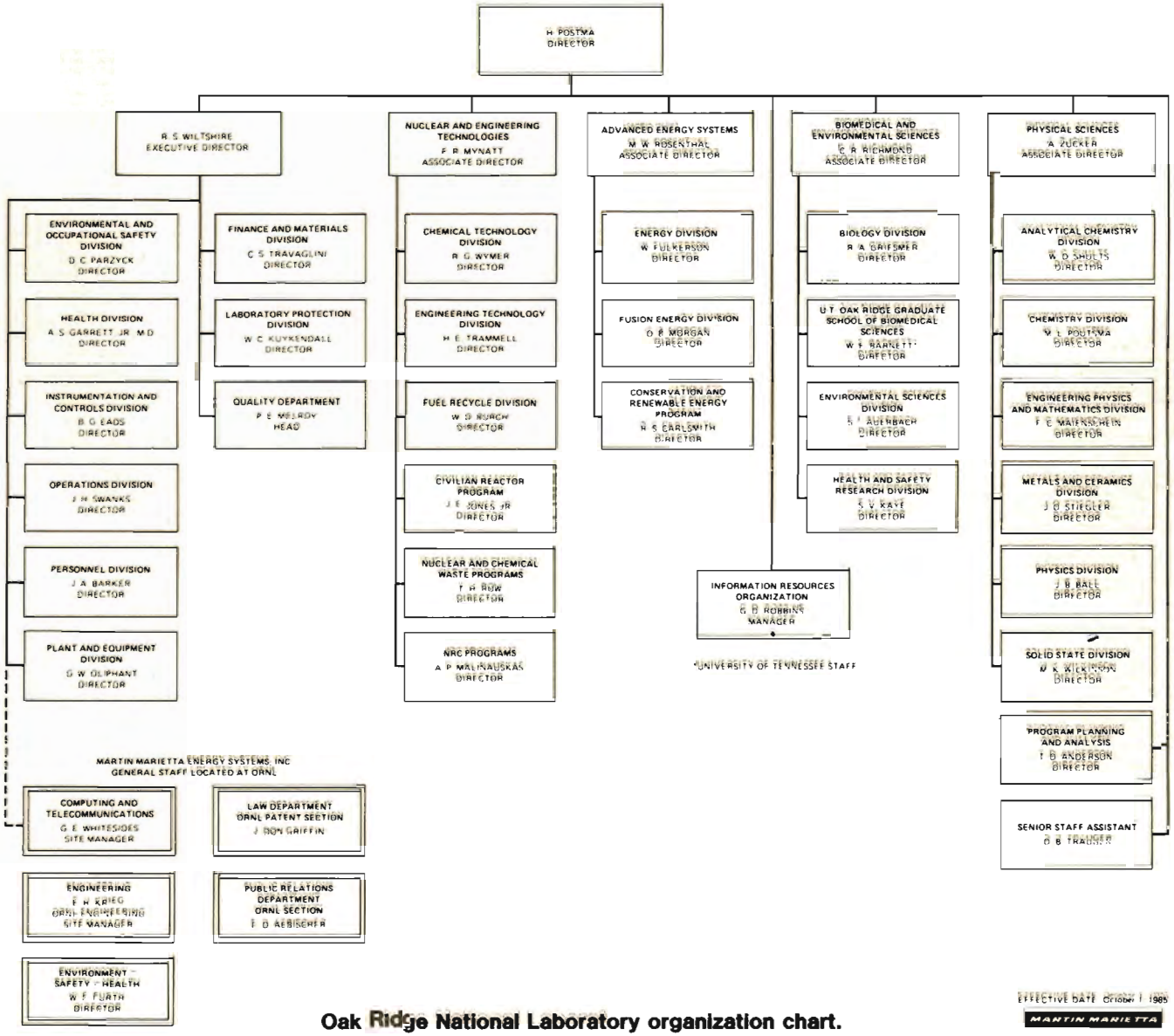
OTHER NONFEDERAL AGENCIES

Total Operating	4.1	4.7	4.3	4.4	3.4	3.4	3.5	3.5	3.6	3.6	3.8	3.8	4.0	4.0		
Technical Personnel	18.9		18.1		15.6		15.8		17.3		18.3		19.8			
Other Direct Personnel	2.8		.8		.8		.3		.3		.3		.3			
Total Direct Personnel	21.7		18.9		16.4		16.1		17.6		18.6		20.1			

Table A.5 (continued)

	FY 1985		FY 1986[a]		FY 1987[a]		FY 1988[a]		FY 1989		FY 1990		FY 1991	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
Work for Others														
Total Operating	148.4	100.3	122.9	111.6	159.5	144.9	166.0	151.0	165.2	150.7	165.8	151.4	166.5	152.1
Capital Equipment	1.7		4.7		9.4		9.9		10.0		10.0		10.0	
Total Asst Secretary	150.1		127.6		168.9		176.0		175.3		175.9		176.6	
Technical Personnel	518.0		649.8		851.4		879.4		876.6		877.6		879.1	
Other Direct Personnel	95.1		118.6		127.0		131.1		130.3		132.6		132.6	
Total Direct Personnel	613.1		768.4		978.4		1010.5		1006.9		1010.2		1011.7	
Total Program Resources														
Total Operating	450.4	398.5	437.5	416.2	525.6	489.8	531.2	508.8	523.1	506.4	524.2	507.0	524.0	507.3
Capital Equipment	22.5		27.0		35.7		32.7		32.9		33.3		33.2	
Construction	6.8		3.2		.0		.0		.0		.0		.0	
Total	479.7		467.7		561.2		563.8		556.0		557.4		557.2	
Proposed Construction	.0		6.8		37.3		69.6		139.7		85.0		72.0	
Technical Personnel	2055.5		2184.3		2461.4		2474.0		2428.9		2444.7		2460.2	
Other Direct Personnel	358.2		354.7		366.9		365.2		361.2		365.8		365.2	
Total Direct Personnel	2413.7		2539.0		2828.3		2839.2		2790.1		2810.5		2825.4	

[a] Escalation factors from FY 1985 to FY 1986 and from FY 1986 to FY 1987 are both 7.0%. Figures for FY 1988 through FY 1991 are in constant FY 1987 dollars.



Oak Ridge National Laboratory organization chart.

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720