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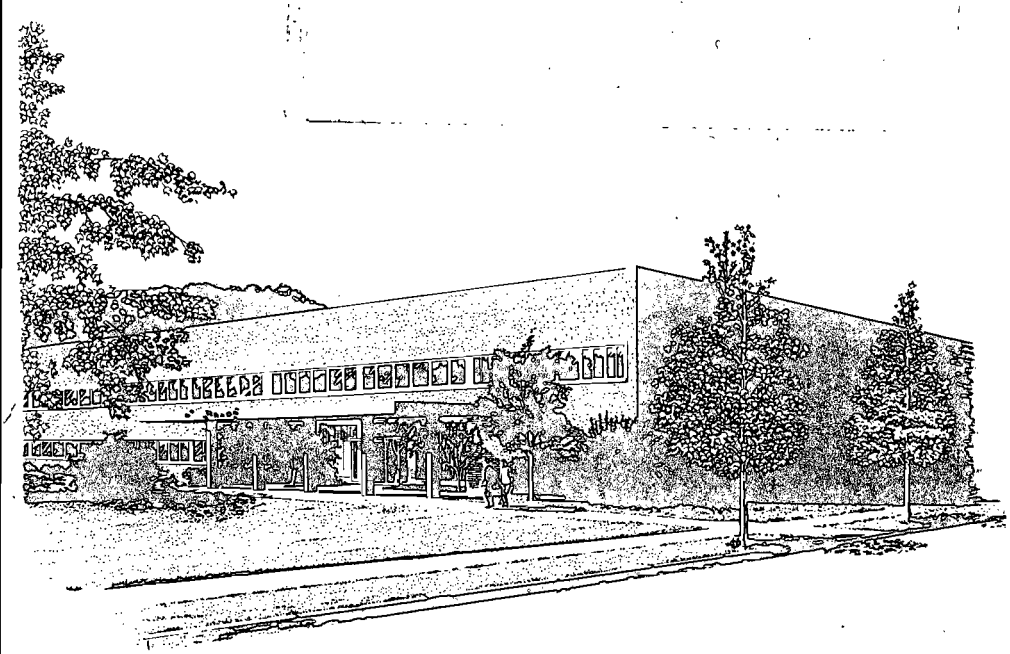
# OAK RIDGE NATIONAL LABORATORY INSTITUTIONAL PLAN FY 1983 - FY 1988

November 1982



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ORNL/PPA-82/3

# Oak Ridge National Laboratory Institutional Plan FY 1983 – FY 1988

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**Senior Planning Group**

H. Postma
C. R. Richmond
M. W. Rosenthal
K. W. Sommerfeld
D. B. Trauger
A. Zucker

**Planning Staff**

S. R. McNeany
T. D. Anderson
B. R. Clark
R. H. Dilworth, III
E. L. Preston
J. W. Roddy
J. D. White

Contract No. W-7405-eng-26

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# DIRECTOR'S OVERVIEW

# DIRECTOR'S OVERVIEW

This overview is written during a time in which several nontechnical events have significantly affected the direction of the Oak Ridge National Laboratory (ORNL). These include the growing government deficit; the economic recession, which is in part energy related; the change in the Administration's policy regarding the role of the federal government; and the Administration's shift in research and development (R&D) priorities. Together, these events have caused major funding reductions in many of the more recently established programs at the Laboratory and, as a result, a reduction in the ORNL staff of over 700 people during the past two years. More important are the recent examinations of the role of the Department of Energy (DOE) laboratories and their quality of work and productivity by three distinguished groups—DOE's Energy Research Advisory Board (ERAB), the White House Science Council's Federal Laboratory Review Panel, and the President's Private Sector Survey on Cost Control.

The findings and recommendations of ERAB have formulated a very positive and broadened role for the laboratories and, I believe, reinforce many of the directions in which ORNL has been heading for the past five to ten years. Therefore, this plan has been developed under the assumption that ERAB's recommendations will form the basis for the findings of the other two committees, whose work is not yet complete, and that most of the recommendations will be implemented in the next few years. Of the many recommendations emerging from the committees, we assume certain basics ought to be implemented. DOE should choose the best performer for a job. Organizational inefficiencies in funding procedures that are now obstacles to the full utilization of the laboratories' capabilities should be corrected. The laboratory directors should be given greater flexibility in the use of funds within overall budgets and guidelines. And, particularly, the laboratories as "corporate" entities should strengthen cooperation with industry and universities through subcontracting, increasing the capabilities of user facilities, accepting guest assignees, participating in joint programs, and continuing technology transfer activities.

As these recommendations are implemented, we will find the Laboratory moving in the direction of greater efficiency. Less time will be spent in writing management reports, on justifying existences, and in competing for funds, and thus our valuable personnel will be able to resume their proper function—performing important R&D. The net productivity of the entire institution will increase; more work will be performed for the same amount of money as in the past.

We are basing this plan on the assumption of increased productivity and efficiency in R&D at ORNL. We also assume that the Administration's policies and priorities, which have been changing as a result of budget negotiations with the Congress, will stabilize following resolution of the 1983 budget. In 1984 should come consolidation, focus, realignment, and a return to more stable research programs.

Unfortunately, the debates between the Administration and the Congress have not yet clarified the plans

for all the nation's technical programs. Until those plans are clearly defined, we must make judgments, to the best of our ability, about the will of the country with respect to such important programs as the breeder reactor, fuel reprocessing for the breeder reactor, the high-temperature gas-cooled reactor, the biological and life sciences programs, and the conservation and fossil energy programs. Despite the absence of a national consensus on these technical programs, we believe that aggressive application of all the Laboratory's resources to national problems, while maintaining strong relationships with universities and industry, will lead to maximum benefit for the country as a whole.

We anticipate that much of the feedback from this plan will come directly from the Administration and that we may well be at variance with the Administration's projected policies. Nevertheless, we believe this plan, like those of the past, ought to be a reasonable estimate of the final agreements between the Administration and the Congress rather than a mere accommodation of the Administration's point of view.

Herman Postma

Herman Postma, Director

# ROLE STATEMENT OF THE OAK RIDGE NATIONAL LABORATORY

# ROLE STATEMENT OF THE OAK RIDGE NATIONAL LABORATORY

The primary objective of the Oak Ridge National Laboratory (ORNL) is to support national fission and fusion energy goals through scientific research and technology development. Even though nuclear energy represents the major endeavor, the Laboratory also plays important roles in other areas of energy research and development (R&D) including conservation and fossil energy. Emphasis is on high-risk, high-payoff technology development and on generating scientific and technical data (e.g., energy-related health, safety, and environmental data). ORNL concentrates its R&D efforts on nationally important scientific and technological problems that are not appropriate for the private sector or for universities to undertake. The private sector does not undertake such R&D projects because the necessary financial incentives are lacking. The universities do not undertake these projects because of the project size or because a multidisciplinary approach requiring long-term continuity is needed. In support of this objective, the Laboratory carries out strong base technology research programs in engineering and in the physical, environmental, and biological sciences.

Energy technology development at ORNL emphasizes the fission nuclear fuel cycle and magnetic fusion and includes other important efforts in residential and commercial energy conservation and in some areas of coal conversion and utilization. The technology areas in which ORNL participates involve high risks that industry finds unacceptable. In addition to ORNL's participation in the development of major energy technologies, the Laboratory maintains lesser involvement in other technologies (e.g., geothermal, electric energy systems, energy storage, etc.) in which existing facilities and expertise offer unique capabilities to the Department of Energy (DOE). ORNL also serves as a technical program manager for DOE in specialized areas of technology development in which we have special competence.

Another primary role of ORNL is to identify and provide solutions to generic research problems in energy-base technologies particularly in materials, separation techniques, chemical processes, biological screening, and biotechnology. In carrying out this role, ORNL conducts basic research in physical and life sciences to provide a solid scientific basis on which decisions about the various energy technology options can be made.

The philosophy of reinforcing fundamental thrusts of a few, well-chosen technologies (multiprogram) with broad, long-term, and more basic research in a variety of pertinent disciplines (multidiscipline) characterizes ORNL in the role of a multiprogram laboratory. This role is broadened by including a few areas of more basic research in which ORNL generates, analyzes, and systematizes new fundamental knowledge by virtue of the Laboratory's stewardship of unique or rare national facilities and resources

such as reactors, the National Environmental Research Park, animal research facilities, and heavy-ion facilities.

A signficant non-R&D role performed by ORNL is in the manufacture, production, and sale of radioactive and stable isotopes that are not available from the private sector. These are distributed for use by the medical, industrial, and research communities.

The Laboratory also does work for the Nuclear Regulatory Commission and, in areas where DOE has a program interest and facilities exist, undertakes work for other federal agencies such as the Department of Health and Human Services and the Environmental Protection Agency. This work for others amounts to about 20% of the Laboratory's program.

ORNL expends special effort to transfer technology to the private sector; to involve industry, where appropriate, in ORNL programs; and to encourage cooperative uses of facilities, both formally in users' groups and informally through professional contacts and participation. Similarly, ORNL provides universities with ready access to major research facilities and programs. At ORNL, users have access to state-of-the-art research capabilities, training facilities for faculty and students, and an opportunity for collaborative research using facilities and techniques that are not available to universities.

Finally, ORNL plays a special regional role for energy-related activities in the southeastern United States by providing universities access to its facilities, engaging in energy technologies that are of interest in the Southeast, and supporting and collaborating with other institutions—state and local governments and organizations such as the Tennessee Valley Authority—that have primary R&D influences in the area. ORNL is aiding the state in its initiative to develop a high-technology industrial base. In addition, ORNL is linked to other DOE-sponsored development activities in the Oak Ridge area, such as the Clinch River Breeder Reactor, the uranium enrichment programs, and support to DOE's Oak Ridge Operations Office.

# LABORATORY RESOURCES SUMMARY

# LABORATORY RESOURCES SUMMARY

## *Resources*

Oak Ridge National Laboratory's (ORNL's) most valuable resource is its people; and over the years, the level of this resource has varied significantly. Figure 1 shows that the Laboratory's peak employment occurred in FY 1968. Between FY 1968 and FY 1974, personnel levels declined sharply, but this trend was reversed with a strong growth in staff during the next four years. By FY 1978, our staff level was at about the same level as a decade before. From FY 1978 through FY 1981, however, the Laboratory's population grew at less than 1% per year, and sharp decreases in manpower levels have been made in anticipation of the FY 1983 budget. Major budget cuts in certain programs caused us to reduce our personnel level by nearly 15% from the FY 1981 level. After FY 1984, some very small growth is projected, but levels are expected to remain well below our recent manpower peaks in FY 1981 and FY 1968. Considerable support from DOE will be necessary to keep erosion of Laboratory resources from accelerating.

ORNL's operating budget, which provides the support for our personnel levels, is shown in Fig. 2. Although our budget increased considerably in the late 1970s, it has been declining since FY 1980; we received a 10% real reduction in our FY 1983 budget compared to the FY 1982 budget. After FY 1984, some modest growth is projected to occur, but our FY 1988 operating costs (in constant dollars) are still projected to be more than 8% lower than the FY 1982 costs.

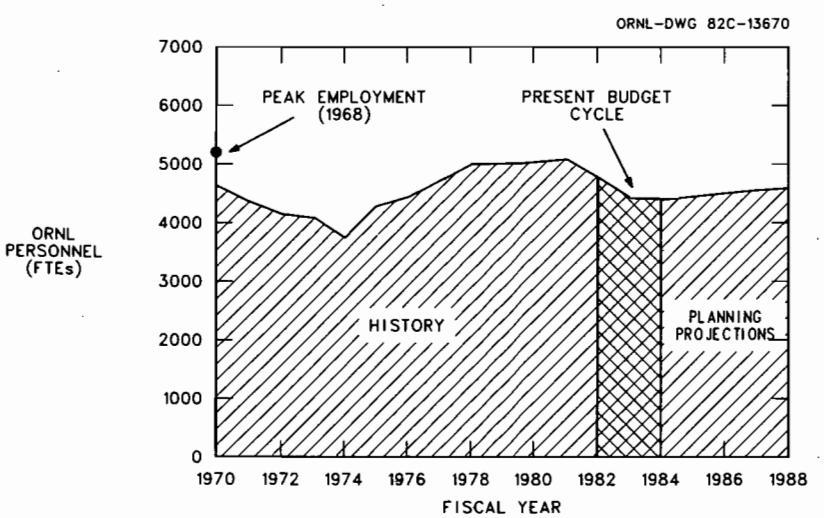


*Fig. 1. ORNL personnel levels are expected to decrease through FY 1984.*

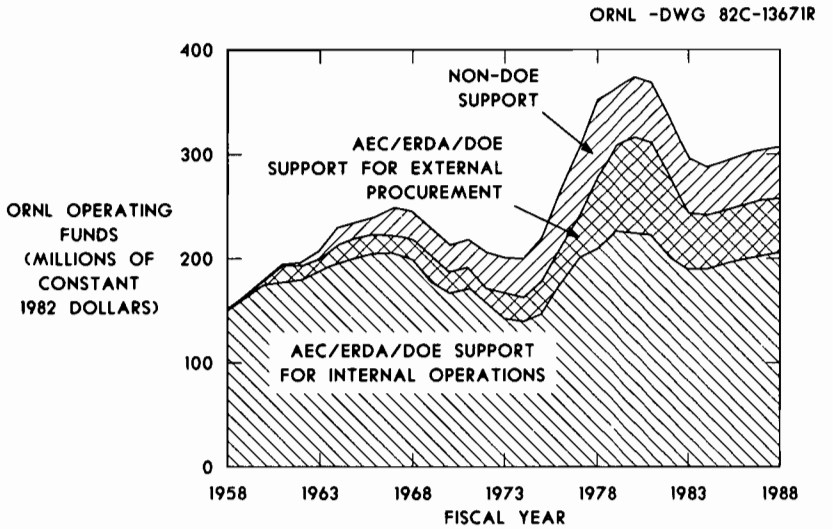


*Fig. 2. The Laboratory's FY 1983 operating budget has decreased by 10% compared with the FY 1983 budget; in FY 1988, ORNL's budget will still be more than 8% lower than the FY 1982 budget.*

In addition to our own staff and facilities, the Laboratory is able to use the resources of many other organizations. Visiting researchers from universities, foreign research centers, and U.S. industry and government often collaborate with ORNL scientists, and they offer fresh insights and special capabilities and supplement the Laboratory's professional staff by 15 to 20%. Through cooperative programs with the Tennessee Valley Authority, universities, and industry, ORNL makes use of the staff and facilities these organizations can provide. The Laboratory also makes extensive use of resources available within other organizations of the Union Carbide Corporation–Nuclear Division at Oak Ridge.

The Laboratory is organized along both functional and programmatic lines into a matrix organization. This type of organization enables ORNL to provide a flexible and coordinated response to the needs of the Department of Energy (DOE) and other sponsors while maintaining a stable environment for research. An organization chart of the Laboratory is presented in the Appendix.

## DOE Programs

Since 1979, the Office of Energy Research (OER) has been our largest single supporter; since DOE's 1981 reorganization, this office has been funding over 40% of our total effort (Fig. 3). The director of OER has overall responsibility for the Laboratory. The Office of Nuclear Energy, the Office of Defense Programs (which funds ORNL's defense waste work), the Office of Conservation and Renewable Energy, and the Office of Fossil Energy also support large efforts at the Laboratory. Another important effort is performed in support of the Energy Information Administration.

The major areas of work at ORNL are in fission energy, basic physical sciences, biological and environmental sciences, magnetic fusion, conservation, and fossil energy (Figs. 4 and 5). Most of these areas are supported by several sources, including both DOE and non-DOE organizations. For example, in 1982 ORNL's fission funding came from the Assistant Secretary for Nuclear Energy, the Nuclear Regulatory Commission (NRC), the Assistant Secretary for Defense Programs (for our defense waste work), and other sources.

The production and distribution of stable and radioactive isotopes that are not available from the private sector is another important program conducted by ORNL. Through this program, ORNL serves as the U.S. distributor of isotopes to many federal, nonfederal, and foreign customers.

Over the last decade, the Laboratory's technology programs (fission, fusion, fossil, and conservation) have grown more rapidly than programs in basic physical and life sciences, which resulted in a shift in the balance between these two efforts (Fig. 6). Little change is expected in the current balance over the planning period.

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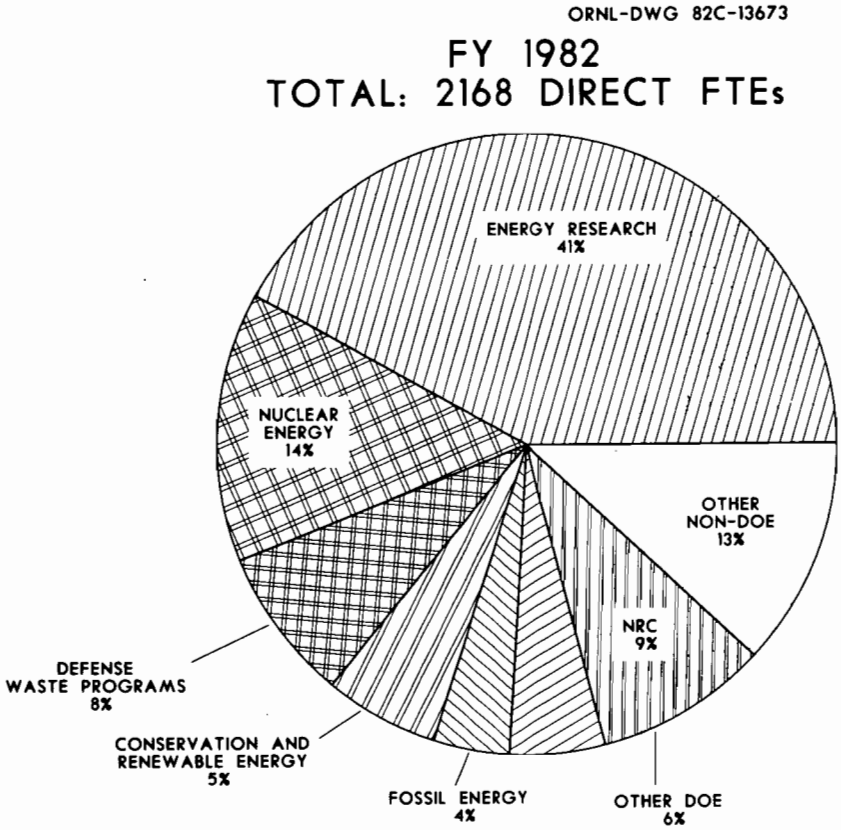


*Fig. 3. The OER is estimated to support over 40% of ORNL's direct FTEs since the 1981 DOE reorganization. Other major DOE sponsors include the Offices of Nuclear Energy, Defense Waste Programs, Conservation and Renewable Energy, and Fossil Energy.*

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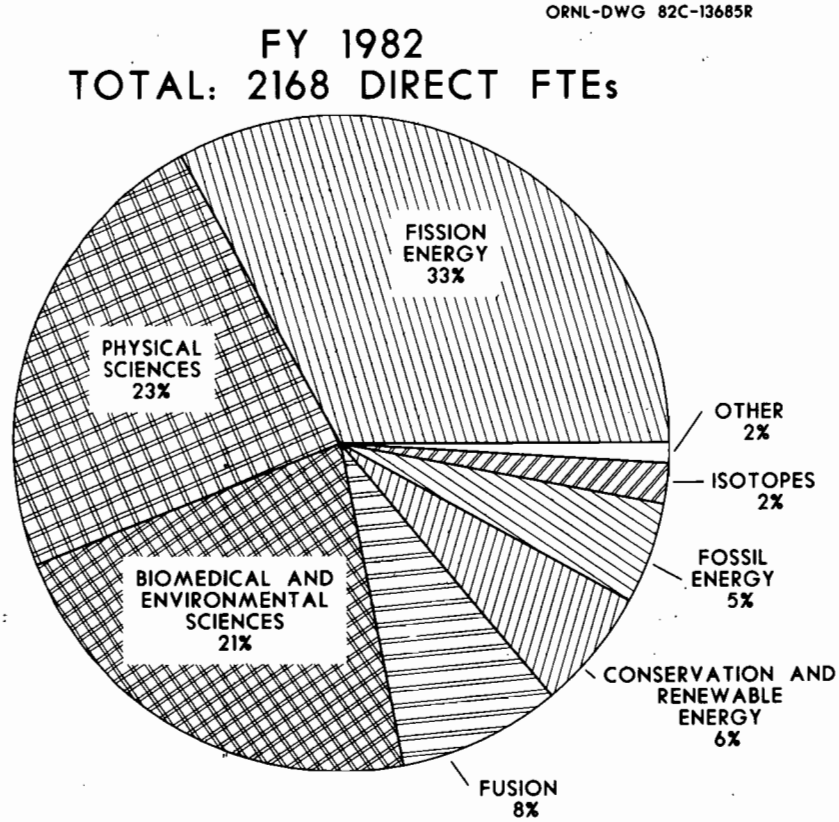


*Fig. 4. As a percentage of FTEs, Fission Energy is the largest ORNL program area, but large efforts are carried out in many other areas. (These program areas are defined internally by ORNL and do not necessarily correspond directly with DOE's program structure.)*

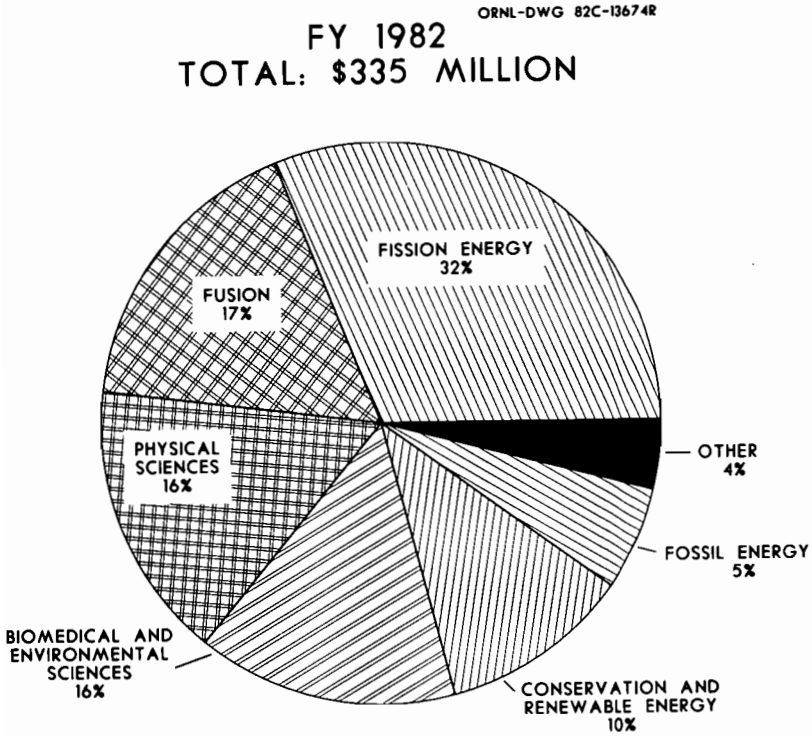


*Fig. 5. ORNL program areas as a percentage of the total operating budget.*

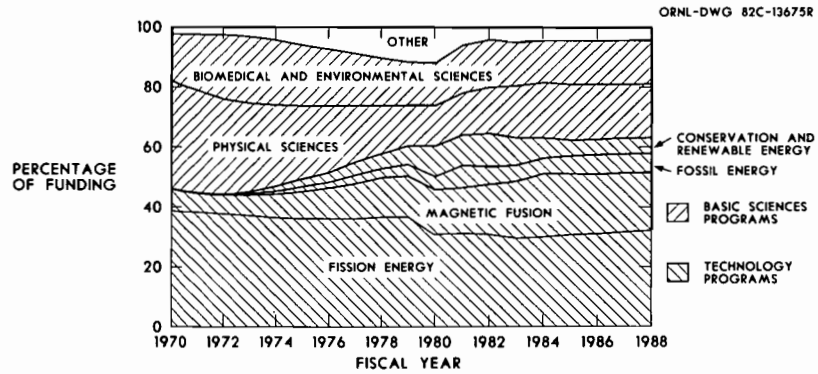


*Fig. 6. The balance between the basic sciences programs and the technology programs has shifted over the last ten years.*

## *Non-DOE Programs*

Over 30 non-DOE sponsors currently fund the work of about 20% of the Laboratory's direct full-time equivalents (FTEs) (Fig. 7). NRC is our largest non-DOE funding source, supporting 189 direct FTEs. Our research support for this agency is mandated by the Energy Reorganization Act of 1974. Most of our other non-DOE sponsors, including the Environmental Protection Agency (EPA) and the Department of Health and Human Services, fund various life sciences programs at ORNL. The relatively large EPA support has resulted, in part, from transfers of funds from DOE to EPA in 1979.

The Laboratory and DOE have benefited greatly from these non-DOE programs. Through these efforts, we have been able to enter or develop new areas of research that have proven useful to DOE. Non-DOE funding has been particularly valuable in complementing DOE research in the life sciences; we may also be able to augment our social sciences and other capabilities for DOE needs through non-DOE funding sources. Each program from other sponsors is approved by DOE and complements DOE's own pro-

grams; thus, DOE receives significant benefit while the Laboratory is able to maintain institutional and programmatic flexibility.

The current proportion of non-DOE work is not expected to increase over the next five years (Table 1).

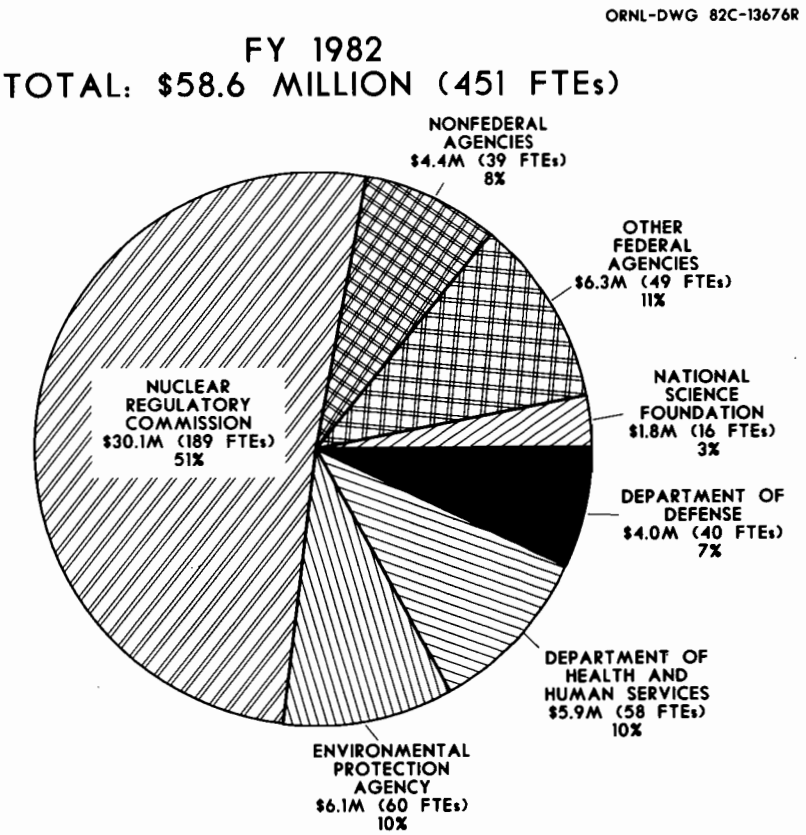


*Fig. 7. NRC sponsors about one-half of ORNL's non-DOE work.*

**Table 1. Non-DOE sponsored work**

| | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 |
|---|---|---|---|---|---|---|---|
| Total direct FTEs | 2168 | 2044 | 1992 | 2019 | 2063 | 2084 | 2107 |
| Direct FTEs sponsored by NRC | 189 | 195 | 171 | 171 | 171 | 171 | 171 |
| Other non-DOE direct FTEs | 262 | 263 | 249 | 261 | 271 | 273 | 275 |
| Total non-DOE direct FTEs | 451 | 458 | 420 | 432 | 442 | 444 | 446 |
| Non-DOE work as a percentage of total Laboratory effort | 20.8 | 22.4 | 21.1 | 21.4 | 21.4 | 21.3 | 21.2 |

# SCIENTIFIC AND TECHNICAL ACTIVITIES

# SCIENTIFIC AND TECHNICAL ACTIVITIES

## *DOE Effort*

### Director of Energy Research

The Department of Energy's (DOE's) Office of Energy Research (OER) is the largest single sponsor of research at the Oak Ridge National Laboratory (ORNL). Over 40% of ORNL's operating budget comes from this office. In return, the Laboratory conducts major research programs for OER in the areas of basic physical sciences, fusion energy, and biomedical and environmental sciences (Table 2).

#### *Basic Physical Sciences (KA, KB, KC)*

Nine ORNL divisions conduct basic research that is supported by the OER. Activities include nuclear and high-energy physics and a broad spectrum of research in the nuclear, chemical, and materials sciences that is supported by OER's Office of Basic Energy Sciences (BES).

#### *Technical Progress and Future Directions*

The nuclear physics program concentrates on heavy-ion research. The Holifield Heavy Ion Research Facility (HHIRF) houses the accelerators and instruments that are dedicated to heavy-ion studies.

During the past year, several milestones were reached in bringing the new tandem accelerator facility into full operation. These milestones were the first demonstration of coupled tandem-cyclotron accelerator operation, the first operation of the new data acquisition system, and the first period of operation for scheduled experiments. Under a very unusual funding arrangement, a user support building, the Joint Institute for Heavy Ion Research, was completed and put into service. Half of the funding for the Joint Institute was provided by Vanderbilt University and The University of Tennessee. First operation for experiments covered a five-month period. Full-time operation for experiments continued in June 1982.

Some very interesting data were obtained in the last year. Especially significant are studies that use the spin spectrometer detector to obtain data related to nuclear motions and shapes. Determination of the properties of nuclei at extremely high rotational frequencies (approaching fission) and the determination of nuclear resonances are current research emphases.

A major effort in the near term will be to bring the HHIRF into full operation and to develop new state-of-the-art experimental devices. The HHIRF provides a unique resource for heavy-ion research, and effort is continuing to improve accelerator efficiency and reliability—very important factors because a significant number of the facility users will be nonresident scientists working on tight schedules.

**Table 2. Program funding support from the Office of Energy Research**

Millions of dollars—BA

| | FY 1982 | FY 1983 | FY 1984 |
|---|---|---|---|
| **AT—Fusion Energy Research and Development** | | | |
| Total operating | 55.8 | 64.2 | 80.5 |
| Capital equipment | 9.5 | 12.1 | 7.1 |
| Construction | 19.4 | 0.0 | 25.0 |
| **HA—Environmental Research and Development** | | | |
| Total operating | 20.2 | 16.4 | 20.5 |
| Capital equipment | 1.6 | 1.5 | 1.6 |
| Construction | 1.0 | 0.0 | 0.0 |
| Proposed construction | 0.0 | 1.5 | 0.0 |
| **HB—Life Sciences Research and Nuclear Medicine Applications** | | | |
| Total operating | 7.9 | 6.6 | 8.2 |
| Capital equipment | 0.3 | 0.4 | 0.4 |
| **KB—Nuclear Physics** | | | |
| Total operating | 8.7 | 9.1 | 10.1 |
| Capital equipment | 1.1 | 1.0 | 1.0 |
| Construction | 0.4 | 0.0 | 0.0 |
| Proposed construction | 0.0 | 0.0 | 28.5 |
| **KC—Basic Energy Sciences** | | | |
| Total operating | 41.2 | 48.6 | 57.0 |
| Capital equipment | 3.5 | 5.1 | 7.4 |
| Proposed construction | 0.0 | 0.0 | 3.9 |
| **KD—Technology Assessment Projects** | | | |
| Total operating | 1.3 | 1.0 | 1.2 |
| **Miscellaneous (KA, KE)** | | | |
| Total operating | 0.7 | 0.8 | 1.0 |
| **Total—Office of Energy Research** | | | |
| Total operating | 135.9 | 146.8 | 178.5 |
| Capital equipment | 16.0 | 20.1 | 17.5 |
| Construction | 20.9 | 0.0 | 25.0 |
| Proposed construction | 0.0 | 1.5 | 32.4 |

On a longer time scale, design studies are planned for a new and more powerful booster accelerator to replace the existing cyclotron booster. Upgrading the facility by providing at least an order-of-magnitude increase in projectile energies, within this decade, is a definite goal.

Major components of work in the nuclear sciences are: the production, separation, and study of actinide elements; the measurement of neutron cross sections relevant to fusion and fission reactor development; and the preparation of special isotopes.

Actinide research is highlighted by neptunium studies. A recent discovery is that $^{237}$Np is much more toxic than even $^{239}$Pu. The poorly understood chemistry of neptunium as it relates to waste isolation and migration in the environment is, therefore, receiving more emphasis. Recent work has concentrated on aqueous solution complexation reactions of neptunium(V) ions and on neptunium adsorption behavior on hydrous oxides and other potential backfill materials. Novel cation-cation complexes formed by neptunium(V) were discovered. In other studies, basic thermodynamic and magnetic properties of actinides and their compounds are measured (up through Bk, Cf, and Es). Investigations are under way to determine if enough $^{254}$Es ($T_{1/2}$ = 276 d) can be produced at ORNL's High Flux Isotope Reactor (HFIR) to furnish a target for superheavy element searches and the production for chemical studies of elements with atomic numbers 101 through 105.

Although the Oak Ridge Electron Linear Accelerator (ORELA) has been the world's leading facility for time-of-flight measurements using intermediate-energy (keV) neutrons, improvements in two European facilities are bringing them close to parity with ORELA. A study is now under way that examines the many advances in accelerator development to determine whether major increases in the pulsed-neutron source strength can be achieved at reasonable cost. The interim finding is that tenfold to hundredfold advances would be quite expensive but might meet multiple objectives. Cost-effective but relatively minor improvements in ORELA facilities are being sought at present.

Stable isotopes production continues to be a highly important nuclear sciences program. However, future funding is still uncertain and must be clarified soon to allow planning for a viable program.

Materials science is the largest BES program and is shared among the Solid State, Metals and Ceramics, Chemical Technology, and Chemistry divisions. This program, which is guided by the needs of the DOE missions, deals with fundamental studies of

mechanical, physical, chemical, optical, electrical, and magnetic properties of materials.

Important basic experimental research is performed on diverse problems having to do with energy-related materials, such as radiation effects in fission and fusion reactor materials, photovoltaic conversion in solar cells, storage of nuclear wastes in minerals, fast-ion conduction in solid electrolytes for batteries and fuel cells, and flux-line pinning effects in type-II superconductors for magnets. Closely coupled to the experimental work are the theoretical studies that involve state-of-the-art investigations, including relevant extensions of existing theories as well as the development of new concepts, theories, and procedures when appropriate. The theoretical research falls very generally under the classifications of electronic and magnetic properties, lattice dynamics, surface physics, particle-solid interactions, laser annealing, and theory of alloys.

Materials preparation and characterization are major components of the program. Ceramic processing emphasizes designing materials for use at elevated temperatures and developing an understanding of mechanical properties at elevated temperatures. Metallic alloys based on Ni3Al are being prepared, and their properties are being controlled by thermal-mechanical processing as well as by microalloying. Titanium diboride is being prepared by homogeneous nucleation from gaseous phases, and various techniques are being used to improve the mechanical, high-temperature properties of this ceramic.

The newly developed techniques of ion-implantation doping and pulsed-laser annealing are being used to modify the surface properties of many types of materials. These surface modifications significantly affect such phenomena as friction, wear, corrosion, catalysis, and superconductivity, as well as the electronic properties of semiconductors. Recent studies of ion-implanted ceramic materials have demonstrated that the mechanical properties of ceramic surfaces can be controlled by selective implantations and thermal annealing. The continuing development of laser-annealing techniques has resulted in routine laboratory production of very high efficiency, single-crystal silicon solar cells. The strong interest in the alteration and analysis of surfaces of materials by both in-house and outside users has resulted in a new initiative at ORNL to establish a center for surface modification research.

Synchrotron radiation is rapidly becoming another major tool in materials studies. For example, a very significant experiment was recently conducted using synchrotron x-rays to give nanosecond time-resolved diffraction measurements of the temperature and structure of silicon during pulsed-laser annealing. These measurements directly support the thermal melting model of laser annealing in semiconductors and demonstrate the unique capabilities of synchrotron x-ray sources for investigating transient phenomena.

Several large, unique facilities are available at ORNL for research in the materials sciences. Included among them are (1) a variety of neutron-scattering facilities at the HFIR, which furnishes the most intense beams of thermal neutrons now available for research; (2) facilities at the Bulk Shielding Reactor for closely controlled investigations of radiation effects at very low temperatures; (3) several accelerators for research in ion radiation damage, ion implantation, ion scattering, and ion channeling; (4) high-voltage and high-resolution electron microscopes; and (5) a unique 10-m small-angle x-ray scattering camera. Users' groups have been formed for many of these facilities so that they will be readily accessible to scientists within and outside ORNL. The Laboratory is designing and constructing equipment to be installed at the National Synchrotron Light Source; it will have a flexible x-ray scattering facility with a very efficient focusing device and a multipurpose facility on the vacuum uv ring for surface studies.

Chemical sciences work is conducted in four ORNL divisions. Analytical research in the Analytical Chemistry Division currently emphasizes microwave, positron, optoacoustic and mass spectroscopic measurements. Laser-based techniques are prominent.

In the Chemistry Division there are diverse activities. A unique combination of techniques is used to obtain basic thermodynamic and kinetic data on aqueous solutions under the high pressures and temperatures common to energy production facilities. Recent results have included the two-liquid phase separation behavior of aqueous sodium and potassium phosphates in the region of interest in reactor corrosion problems (200 to 400°C) and the aqueous iodine hydrolysis

and disproportionation reactions of interest in accidents like that at Three Mile Island.

Basic research on coal attempts to ensure that this resource is used to best advantage. A combination of instrumental and chemical techniques is used to elucidate the structures of the organic molecules in coal and their functional groups and reactions. Work with model compounds, as well as coal itself, is an integral part of the approach because native coals are too complicated to understand otherwise. Recent results have included the development of ultrahigh-resolution nuclear magnetic resonance techniques for studying functional groups and carbon structures in native, chemically modified, and thermally altered coals; the use of electron spin resonance to study free radical processes in pyrolyzing hydrocarbons; and the elucidation of molten salt catalytic mechanisms in hydrogen shuffling and condensation reactions of model compounds for coal.

In a program of far-reaching significance, electron spectroscopy at synchrotron sources is now providing the best and most comprehensive basis for evaluating molecular orbital theory and photoelectron dynamics. Experiments on core as well as valence orbitals hold a promise for a new approach to the study of chemical bonding. Recently, studies have been completed on diverse gaseous systems including metallic vapors, such as silver, and relatively complicated multiatom organic molecules, such as carbon tetrachloride and ethylene.

The Chemical Technology Division carries out engineering research in resource recovery and recycling as well as separations development. Fuel cycle chemistry is an important component of the separations program and is essential to closing the fuel cycle.

The BES Division of Engineering, Mathematics, and Geosciences supports important programs at ORNL. The Geosciences Program addresses the broad areas of physical chemistry of hydrothermal solutions and materials and of rock-water interactions to 500°C and 100 MPa. Also, high-temperature–high-pressure studies of silicate melts will simulate conditions applicable from the earth's surface to a depth of 35 km (to temperatures of 1200°C and pressures of 1000 MPa). Important geochemical questions addressed include rock metamorphism and alteration, the generation of magmas, and the responses of rock to circulating natural waters. Practical considerations include data bearing on waste storage, geothermal power, and solution mining.

The Engineering Science Center, a new initiative last year, still requires support, and a formal proposal was submitted to DOE in April 1982. The proposal is for a comprehensive center for engineering systems advanced research.

## *Technology Assessment Projects (KD)*

ORNL is conducting a program assessing selected energy technologies and research programs. The broad objective of this work is to investigate the appropriateness and quality of DOE research programs in those areas designated by the sponsors. The assessment projects respond to needs of the Energy Research Office of Program Analysis and the Energy Research Advisory Board (ERAB).

Recent investigations have included an assessment of biomass technologies and an assessment of the BES program of the OER. To be completed within FY 1983 are a study of alternatives for future use of the DOE multiprogram laboratories, a study of the benefits derived from the OER's Health and Environmental Research programs, and assessments of selected topics in solar and conservation research and development (R&D). In most cases, a data base is developed to be used by ERAB or by OER decision makers to develop programmatic recommendations.

## *Fusion Energy (AT)*

Since 1969, the ORNL fusion program has emphasized tokamaks and the technologies supporting them. The past year has seen a shift of emphasis toward more extensive studies of the ELMO Bumpy Torus (EBT) confinement scheme through the proof-of-principle experiment, the EBT-P, and toward the study of improved closed-flux-surface toroidal confinement schemes through the Advanced Toroidal Facility (ATF-1). Expected completion dates are 1987 for EBT-P and 1986 for ATF-1.

The broad-based ORNL technology program has made significant contributions in the areas of plasma heating, pellet fueling, superconductivity, and materials studies; these activities will continue to receive funding support for experimental work at ORNL and other laboratories. During the next five years, an

increased emphasis will be placed on radio-frequency plasma heating.

The ORNL budget for fusion may expand slightly because of EBT-P and subcontracts, but the growth in professional staff will be small. A strong effort will be made to further increase the already significant involvement of industry and universities in ORNL fusion programs.

**Applied Plasma Physics (AT 05).** The theoretical plasma physics program will continue to develop and apply theories and models of plasma behavior in the tokamak, torsatron/stellarator, and EBT configurations. Tokamak-related work will include continuation of the successful collaboration with the Impurity Study Experiment (ISX-B) experimental staff on magnetohydrodynamic activity and beta limits, as well as support for the tokamak Fusion Engineering Device (FED) studies. Efforts will continue to model EBT confinement, with emphasis on the effects of high beta in the core plasma. The study of torsatron/stellarator systems having externally applied helical magnetic fields has grown rapidly in the past year and will continue to support the ATF-1 program.

Work continues in the applied plasma physics effort to develop advanced laser diagnostics. For example, a multichord Faraday rotation system has been developed to measure the plasma current profile of ISX-B. The new system began operation in FY 1982.

The compilation and dissemination of atomic data for fusion will continue. Included are in-house measurements of the cross sections of multicharged ions and the development of atomic collision theory to allow prediction of a broad range of atomic data applicable to plasmas.

**Tokamak Systems (AT 10 10).** Considerable progress has been made in understanding beta limits in tokamaks by using the ISX-B device and with the collaboration of the theory staff. This work will continue into 1984 with improved experimental capabilities. In parallel, programs will continue on impurity studies, electron-cyclotron heating, magnetic ripple effects, pellet fueling, diagnostic development, and plasma-materials interactions. Reduction of the ISX-B program will start at the beginning of 1984 in preparation for ATF-1.

The broadened interest of DOE and of other fusion laboratories in producing a toroidal confinement device with characteristics improved over the basic tokamak concept has prompted the initiation of the ATF-1 program at ORNL. Studies have been made of a wide range of alternative systems having externally applied magnetic fields, and a design choice will be made in late 1982. Installation of ATF-1 will begin in FY 1985, and the first operation is planned for FY 1986.

**Elmo Bumpy Torus (AT 10 20).** The current experimental program on the scaled-up version of the EBT, the EBT-S, has been expanded in support of the advance toward EBT-P. Higher power electron-cyclotron heating has been applied using a 200-kW, 28-GHz, continuous wave (cw) gyrotron from Varian. Confinement scaling has been studied, and the overall diagnostic capability is being increased. McDonnell Douglas has joined in two collaborative programs, one of which has successfully demonstrated the feasibility of ion-cyclotron resonance heating on EBT-S, and the other is now studying the interaction of limiters with the EBT plasma. A divertor for EBT-S has been designed by Westinghouse. The EBT-S program will continue studies in these areas until its planned shutdown about a year prior to EBT-P operation.

As currently planned, McDonnell Douglas will design, construct, and make initial tests on the EBT-P device and will also collaborate with ORNL in experimental operations. If funding is provided as shown in the appended resource projections, operation will begin during FY 1987. The ORNL superconductivity section has built developmental magnets and successfully tested a conductor suitable for EBT-P at full-field values. Installation has begun on a microwave development test facility in which EBT-P components can be tested.

**Development and Technology (AT 15).** Superconducting magnets, materials development, and plasma heating systems are the major activities in this category of work. The first coil for the Large Coil Program is to be delivered in 1982. Testing will begin in FY 1983. The remaining coils will be delivered in FY 1983 and FY 1984 which will lead to full-scale, six-coil testing in FY 1984. Development work will continue on the high-field superconductor that is suitable for operation at 12 T. Work will also

proceed on internally cooled superconductors for fusion-type application.

Long-pulse neutral beam development began in 1982 and will continue through 1984 to provide an alternate source option for the Mirror Fusion Test Facility (MFTF-B); the MFTF-B is located at Lawrence Livermore National Laboratory. Program plans are now under development that would establish a major ORNL program in the technology of radio-frequency plasma heating. In the national gyrotron program, Varian has operated a new 60-GHz gyrotron at 200-kW pulsed and at somewhat reduced power levels cw. Work will also continue on improved acceleration of frozen hydrogen pellets for plasma fueling, on characterizing the plasma-wall interaction, and on developing techniques for calculating and measuring neutron transport in complex geometries. A major program in developing materials for fusion reactors will continue using the ORNL fission reactors.

The Fusion Engineering Design Center (FEDC) completed a preliminary design for the FED and is now expanding these studies to include alternative tokamak options as well as mirror-based approaches. The FEDC is expected to play an even broader role in the future by providing DOE with objective evaluations of proposed reactor concepts, including related R&D proposals and overall requirements.

Finally, the ORNL fusion program has initiated the process of preparing a generic environmental impact statement (GEIS) for magnetic fusion power systems. A technology basis for a GEIS has been prepared, and the schedule allows for completion of a draft GEIS in FY 1983.

## *Biomedical and Environmental Sciences Program*

The OER provides the largest portion of funding (50%) for the biomedical and environmental sciences program at ORNL. OER's Office of Health and Environmental Research provides support in two categories: Biological and Environmental Research (HA 02) and Life Sciences Research and Nuclear Medicine Applications (HB).

Biomedical and environmental research efforts at ORNL have seen little or no real growth during the past several years. In many areas, the funding level has not received full cost-of-living increases so, in effect, there has been a continued erosion. Other losses were incurred because of operating fund transfers from DOE to the Environmental Protection Agency (EPA) and because of subsequent cuts by the EPA. The proposed funding level for FY 1983 is particularly grave—a reduction of approximately 18% (in real dollars) below the level for FY 1982 is projected. A loss of 25% of the personnel in the Biology Division has occurred.

**Biomedical and Environmental Research (HA 02).** The biological and environmental research program is diverse and encompasses a broad effort to understand the interaction of energy-related pollutants with living organisms and ecosystems, including the transport, chemical evolution, and ultimate fate of such pollutants in the environment. Areas of research include the following: radiation biology, radiation and chemical dosimetry, carcinogenesis, mutagenesis, mammalian genetics, carbon dioxide effects research and assessment, and health and environmental risk analysis. In addition, two unique research resources are supported by the HA 02 budget: the Health Physics Research Reactor (HPRR) and the Oak Ridge National Environmental Research Park (NERP).

Objectives of HA 02 environmental research are to determine the pathways through which contaminants move in the environment (including source, form, and potential concentrations received by man), to identify the potential ecological effects that may result from exploitation or production of energy sources, to determine mechanisms whereby the environment modifies contaminants (either decreasing or increasing their potential hazards), to develop a greater understanding of the fundamental environmental processes whereby contaminants move through the environment, and to elucidate controlling mechanisms for the various ecosystems in the Southeast and Appalachian regions. Level or slightly decreased funding is anticipated during the next several years. This, coupled with uncertainty in the specific energy technologies or mixes of technologies being developed, necessitates a consolidation of our research primarily to environmental transport, fate, and effects. We shall continue to emphasize studies designed to increase our understanding of the mechanisms whereby the environment

modifies contaminants and of how such pollutants move through and cause effects upon the receiving ecosystems.

We shall maintain our basic ecological research in aquatic and terrestrial systems in the Southeast and Appalachian regions. The understanding developed in such studies continues to be valuable input for assessing the potential ecological effects associated with the future development proposed for this region. We anticipate maintaining our research related to nuclear technologies with slightly increased resources. Emphasis will continue to center on chronic releases and the long-term behavior of the radionuclides in typical eastern environments. Expertise is being developed in geosciences that will enable us to more effectively conduct research and analyze waste management issues. Research in support of nonnuclear energy technologies will increasingly emphasize organic and organometallic contaminants and will focus on long-term, low-level dispersion and resulting ecological effects. Continued development in environmental chemistry and efficient utilization of simulation modeling will provide more accurate predictions concerning transport, fate, and ecological effects of organic contaminants.

The principal purpose of the $CO_2$ research program is to develop a scientific basis for assessing the response of the global carbon cycle, particularly changes in atomospheric $CO_2$ concentration, to continued releases of $CO_2$ by fossil fuel combustion. Mathematical models of the carbon cycle are being developed and updated with refinements in basic understanding and with improved estimates of key parameters. Sensitivity and uncertainty analyses provide a basis for selecting aspects of models requiring refinement. During the next five years, the global carbon cycle program activities will undergo a significant expansion to encompass new research in terrestrial carbon dynamics and global carbon cycle modeling, as well as new responsibilities in carbon cycle research management for DOE.

A new information activity is the establishment of the Carbon Dioxide Information Center (CDIC), which is a collaborative effort of four ORNL divisions: Information, Engineering Physics, Environmental Sciences, and Computer Sciences. The CDIC supports the nation's $CO_2$ and climate research programs by collecting, compiling, evaluating, and distributing $CO_2$-related information on atmospheric $CO_2$ measurements, fossil fuel utilization, forest conversion, characterization of ocean properties, and reconstruction of past climates using historical records from ice cores and tree rings. This information is stored in bibliographic and numeric data bases. The CDIC will also collect, evaluate, package, and disseminate computer codes, sample problems, user manuals, documentation, and so forth—sufficient information for analysis by independent investigators. The CDIC will perform research on generic problems of communicating complex multidisciplinary knowledge in the diverse $CO_2$ scientific community.

Health effects research includes the study of carcinogenesis, mutagenesis, and damage to biological systems. Primary attention in the coming years will be given to radiation biology (especially neutron studies), mammalian genetics, and toxicology. Within these subject areas, particular stress will be placed on research that leads to predictive statements about human hazards at low doses, including toxicokinetics, comparative metabolism, and the effect of host factors (sex, age, intercurrent disease, etc.).

In our carcinogenesis research program, high priority will be given to the following areas: fission neutrons and gamma rays, radiation carcinogenesis–time/dose relationships, dose-response relationships in chemical carcinogenesis, bioassay carcinogenesis, and carcinogen activity in human cells. In the mutagenesis research program, mammalian genetics will be emphasized, with particular attention given to mammalian chemical mutagenesis, genetic effects of plutonium, metabolism of mutagens, the freezing of embryos of valuable stocks of mutant mice, and basic research into the genetic basis of mutagenesis.

The biological studies of the Japanese atomic bomb survivors provide invaluable quantitative data on the late effects of radiation exposures. Several recent reports on leukemia incidence in the survivors suggest that current numerical limits for neutron exposures should be reduced by as much as a factor of ten. These reports have had wide-ranging implications with regard to radiation exposure of workers in nuclear facilities. ORNL is continuing a study begun in 1979 of dosimetric data for the survivors. A primary objective of the ORNL study is to determine whether the large leukemia risk associated with low neutron-exposure levels in Hiroshima is real or whether it is

the result of a bias in the current dosimetric data. This work will involve several ORNL divisions, other national laboratories, and consulting firms.

An integrated risk assessment program provides an efficient, comprehensive means to analyze the overall impacts associated with proposed energy technologies. Preparation, on an annual basis, of Health and Environmental Effects Documents (HEEDs) of major emerging energy technologies provides an early warning of any potentially serious impacts of the industry's development, encourages the research community to derive data allowing reduction of uncertainties affecting the accuracy of future risk analyses, and identifies specific areas with high priorities for control technology development. Currently funded risk assessment projects at ORNL include a new effort focused on identifying health and environmental risks potentially associated with the introduction of the Liquid Metal Fast Breeder Reactor (LMFBR) and its fuel cycle and on a second-year expansion of the HEED on coal direct liquefaction. Research personnel from throughout the ORNL community employ state-of-the-art data on fuel cycle engineering, control technology, product use, pollutant emissions, and health effects–dose/response functions to analyze the impacts associated with large-scale introduction of the technology. The Life Sciences Synthetic Fuels Program (LSSFP) serves as a coordinating point for research work directed at evaluating the potential health and environmental impacts of coal conversion technologies. The LSSFP multidisciplinary team of scientists and engineers meets regularly to discuss the directions and results of ongoing ORNL core research programs to ensure communication of results and coordination of efforts among the researchers at ORNL. The LSSFP also serves as the coordinating point for studies that are aimed at evaluating the health and environmental aspects of operating commercial and pilot-scale coal conversion plants such as the University of Minnesota-Duluth gasifier and the H-Coal pilot liquefaction plant. An important activity undertaken by the LSSFP is to interact with technology developers to identify areas where new research efforts are needed, to ensure that ongoing activities are directed at relevant problems, to ensure understanding of process and plant conditions during site studies, and to transfer to industry results of coal conversion health and environmental studies conducted at ORNL.

The HPRR, a unique facility for research in neutron and gamma ray dosimetry, is used in developing both personnel and accident dosimeters. Data obtained from neutron radiobiology experiments correlate biological response and the radiation environment with emphasis on neutron carcinogenesis, dose rate effects, and radioprotective drugs. The HPRR assists universities by providing radiobiology, health physics, and nuclear engineering training. Professors and students take advantage of the HPRR's inherent safety, versatility, and ease of operation to learn basic concepts as well as specific applications. Expanded use of the HPRR over the next several years is expected for many purposes: (1) training of college and university students in nuclear technology and radiobiology; (2) conducting annual international dosimetry intercomparison studies; (3) studying nuclear accident dosimetry and personnel neutron dosimetry; (4) developing and testing criticality alarm systems; (5) supporting neutron radiobiology experiments; and (6) testing physical systems (e.g., pumped lasers, neutron effects on materials, shield effectiveness).

Part of the ORNL Reservation was designated a NERP in 1980. A NERP is an outdoor laboratory in which research may be conducted to achieve goals defined by the National Environmental Policy Act, the Energy Reorganization Act, and the Nonnuclear Energy Research and Development Act. The 5500-ha Oak Ridge NERP lies in the heart of an eastern deciduous forest area of streams and reservoirs, mesic hardwood forests, and extensive upland mixed forests. Elaborate monitoring systems enable users to measure environmental factors precisely and accurately for extended periods. Various sites in the park offer opportunities for aquatic and terrestrial ecosystem analyses such as biogeochemical cycling of pollutants resulting from energy-producing facilities, landscape alterations, and forest and wildlife management. Use of the Oak Ridge NERP by ORNL staff and by staffs of universities and state and federal agencies has increased over the last three years and is expected to continue to increase over the next five years. Current research programs that take advantage of the Oak Ridge NERP include a study of the effects of acid

deposition on vegetation, a study of the effects of whole tree harvesting on biomass production and soil nutrients, and evaluation of the U.S. Fish and Wildlife Service's habitat suitability index models.

**Life Sciences Research and Nuclear Medicine Applications (HB).** The DOE HB program is devoted to the basic study of biological effects that could result from chemical and physical agents associated with energy production and with the production, development, and use of radiopharmaceuticals. Molecular studies of the interaction of potentially hazardous physical and chemical agents in assay systems are necessary to understand potential health risks to man and other organisms. Our basic research utilizes a range of test agents: ultraviolet, ionizing radiation, and numerous chemical pollutants and toxic compounds including atmospheric halogenated hydrocarbons and compounds produced from the use and conversion of fossil fuels. The assay systems employed include as study organisms bacteria, viruses, fruit flies, mice, and many types of human and animal cells in culture. Research encompasses the study of the basic physical and chemical properties of potentially hazardous agents, their mechanisms of interaction and metabolic pathways in biological systems, as well as other biological effects and how these are altered by deoxyribonucleic acid (DNA) repair mechanisms. Thus, studying the function of proteins and nucleic acids is crucial to the understanding of the response of biological systems to environmental effects. Our research continues to investigate the correlation of protein structure with function and to study the mechanisms of DNA replication, recombination, translation, transcription, and processing of ribonucleic acid, RNA, and the repair of altered DNA. High priority will be given to research in the following areas: mechanisms of radiation lethality, chromosome chemistry, gene expression in carcinogenesis, carcinogen-cell genome interactions, and tumor cell immunology.

Certain areas of our basic biological research, however, will be significantly affected by proposed reductions in funding (25% reduction in real dollars). This follows a steady decrease in real dollars over a several-year period. We now are faced with a situation that, if unchanged, will substantially weaken our program and will require a complete restructuring of our research program with the loss of numerous important program elements (i.e., hematopoiesis, carcinogen screening, yeast mutagenesis, protein synthesis, photophysics of macromolecules, molecular genetics, x-ray diffraction, and chemical effects on the immune system).

The Nuclear Medicine Program has 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. Current research focuses on the development of labeled fatty acids, their uptake into the heart and subsequent functioning, and on the perfection of a generator for the production of radioactive $^{191m}$Ir from $^{191}$Os. The generator system may be used to obtain an ultra-short-lived $^{191m}$Ir (physical half life = 5 s) for the evaluation of congenital heart disease in children and general heart function in adults. Other agents being developed are radiolabeled barbiturates and organometallic compounds. The barbiturates may be used to measure changes in brain blood flow. These measurements can then be correlated with various disease states such as those that might result from stroke or tumors. The organometallic compounds are used in cancer therapy research. The Nuclear Medicine Program is complemented by an active extramural collaborative effort through cooperative programs with medical institutions such as Johns Hopkins University and Massachusetts General Hospital.

## Assistant Secretary for Nuclear Energy

The Assistant Secretary for Nuclear Energy is a major sponsor of applied nuclear research at ORNL (Table 3). ORNL's major programs receiving funds from this assistant secretarial office are the LMFBR Program, the Consolidated Fuel Reprocessing Program (CFRP), the High-Temperature Gas-Cooled Reactor (HTGR) Program, and the Nuclear Waste Program.

### *The Liquid Metal Fast Breeder Reactor*

This program is responding to the national policy of promoting the LMFBR concept as part of a general revitalization of the nuclear industry, with prime

**Table 3. Program funding support from the Assistant Secretary for Nuclear Energy**

Millions of dollars—BA

| | FY 1982 | FY 1983 | FY 1984 |
|---|---|---|---|
| **AE—Advanced Nuclear Systems** | | | |
| Total operating | 2.7 | 5.5 | 4.5 |
| Capital equipment | 0.0 | 0.4 | 0.1 |
| **AF—Breeder Reactor Systems** | | | |
| Total operating | 36.7 | 27.6 | 33.2 |
| Capital equipment | 3.6 | 3.0 | 4.6 |
| **AG—Conventional Reactor Systems** | | | |
| Total operating | 8.7 | 6.4 | 6.4 |
| Capital equipment | 0.9 | 1.2 | 2.0 |
| **AH—Remedial Action Programs** | | | |
| Total operating | 0.4 | 1.0 | 1.1 |
| **AP—Commercial Nuclear Waste** | | | |
| Total operating | 1.9 | 1.7 | 1.7 |
| Capital equipment | 0.1 | 0.0 | 0.0 |
| **Miscellaneous (AW, CD)** | | | |
| Total operating | 0.9 | 0.2 | 0.3 |
| **Total—Assistant Secretary for Nuclear Energy** | | | |
| Total operating | 51.3 | 41.0 | 45.8 |
| Capital equipment | 4.7 | 5.3 | 6.6 |
| Proposed construction | 0.0 | 0.0 | 0.0 |

emphasis on the Clinch River Breeder Reactor Plant (CRBRP) Project. During this planning period, ORNL will continue its efforts in the traditional base-technology areas of materials and structures, safety, physics, and measurements and controls; but the Laboratory will also continue its efforts in direct support of the CRBRP. ORNL is already supporting the CRBRP through work on development requirement specifications and through responses to direct requests from the project; the work includes an increasing role in tasks related to licensing. The possibility for a follow-on prototype plant project appears now to depend on whether suitable arrangements can be negotiated with foreign countries such as the United Kingdom or Japan on both the government and industrial sides. Accordingly, ORNL personnel probably will increase their involvement in foreign exchange in several base-technology areas.

In the materials and structures area, we will continue efforts to enhance our understanding of the behavior of reference materials in LMFBR environments, to develop and validate improved inelastic design methods, and to develop and qualify advanced materials so that they meet code standards for full and timely industrial use. Management of the Materials and Structures Technology Management Center will continue, and ORNL will act as lead laboratory for the national Materials and Structures Program; further consolidation of the national program is anticipated and should result in an increased ORNL effort in this area. The physics work will concentrate on confirming and validating shielding design methods as well as on providing and evaluating basic physics data (e.g., fission neutron yields) for specific reactor applications. In the reactor safety area, thermal hydraulics data pertinent to the understanding and management of shutdown heat removal will be obtained. Using full-size simulations of portions of a prototype reactor core design for a commercial-size plant, enhancement and utilization of computerized safety and reliability data bases will continue. Efforts are underway to acquire NRC participation in this data base work. The measurements and controls effort will continue to respond to specific project needs and is expected to grow significantly as ORNL assumes a national lead role in this area.

The Nuclear Standards Management Center, which is part of the Program Assurance effort in the LMFBR Program, will continue to promote the development of consensus industrial standards, augmented by special program standards as required, to ensure that the information and experience gained in all nuclear programs—including fuel recycle and waste management—are documented appropriately and made available to the private sector. The DOE unusual-occurence-report activity will be expanded to include DOE programs other than those for nuclear energy.

Direct CRBRP Project support will increase in areas for which ORNL has special expertise. Examples are developing special instrumentation, such as the high-sensitivity and high-temperature neutron detectors; procuring the flux monitoring channel; determining the properties of special materials, such as the particular concrete to be used in the CRBRP; participating in design reviews; performing and check-

ing shielding calculations; and providing in-residence technical support.

## *Consolidated Fuel Reprocessing*

Fuel reprocessing focuses mainly on uranium-plutonium fuel from the LMFBR but also includes some generic work applicable to the light water reactor (LWR) and HTGR fuel cycles. Although much of the work is performed by the Fuel Recycle Division, created to simplify the overall management of DOE's Consolidated Fuel Reprocessing Program (CFRP), a number of the Laboratory's R&D divisions and the Union Carbide Corporation–Nuclear Division's Engineering Division participate in the program. As lead laboratory in CFRP, ORNL manages related efforts being conducted elsewhere in the country through the CFRP Technical Management Center (TMC). Industrial participation is obtained through numerous subcontracts for systems studies and for design and fabrication of prototypical hardware systems.

As future prospects for the breeder program indicate further extension of schedules for large demonstration reactors, the need to provide an in-place fuel cycle for the Fast-Flux Test Facility (FFTF) and CRBRP has become self-evident; DOE planning is reflecting these changes. Previously, options for a demonstration reprocessing plant with capacity for several large breeders were the primary focus of the breeder reprocessing effort. Now, a more limited-scale and limited-demonstration concept, designated as the Reprocessing Test Facility (RTF), is being examined. Operating funding requirements associated with the construction of the RTF are uncertain, but they may exceed those shown in the appendix to this document. DOE planning efforts in late FY 1982 were directed toward closing the fuel cycle for the FFTF and CRBRP. Options for using existing facilities and emphasizing demonstration goals for the breeder reprocessing program were considered. Overall requirements for plutonium supplies define schedules and impact choices. Closing the FFTF and CRBRP fuel cycle in the coming decade would achieve a major step toward an important long-range goal for the breeder program—self-sufficiency in overall plutonium supplies. Feasibility studies are being performed jointly by the CRFP and the Fuel Development Department of the Hanford Engineering Development Laboratory in which space in the Fuels and Materials Examination Facility would be used for the major reprocessing functions. Many of the important demonstration goals previously identified by the CFRP as needed for breeder reprocessing can be achieved in this facility; however, others cannot be addressed at the scale of this project (100 kg/d) or under the constraints of the existing facility.

Responsibility for Commercial Airborne Waste Management development was assigned to the CFRP-TMC in FY 1982. Experimental work for this program has been conducted at other DOE laboratories, while a significant effort in developing retention schemes for the fission gases has been carried out over the past decade in the fuel reprocessing programs. A plan will be prepared that focuses on the demonstration of airborne waste management technology with an Integrated Hot Off-Gas Facility incorporated in the RTF. This demonstration will include not only the removal of airborne waste constituents from the off-gas stream but also the conversion of airborne wastes to forms suitable for terminal disposition.

Beneficial occupancy of the Remote Operation and Maintenance (ROMD) portion of the Integrated Equipment Test Facility was gained at the end of FY 1981. Testing started almost immediately in ROMD on a mock-up of a chemical processing module similar to those proposed in the conceptual design of the Hot Experimental Facility. The modular design concept places each individual chemical processing step in a single module. Smaller repairs such as the replacement of pumps, valves, and so forth, can be made with the module in place; for major repairs or replacement by advanced equipment, any module can be removed as a unit to a maintenance cell or disposal facility. The testing in ROMD is designed to verify the in situ maintenance of such modules.

The design and fabrication of prototypical equipment systems that will be tested in ROMD are continuing. Tests of the Advanced Technology Liquid Sampler began during the summer of 1982. The continuous rotary dissolver is in place for remote maintenance testing. The detailed design of the remote shear and the remote disassembly system is complete. Integrated cold tests of the head-end systems will begin in FY 1985.

### *High Temperature Gas-Cooled Reactor*

The gas-cooled reactor program at ORNL consists primarily of technology development in support of the national program to develop HTGRs for power and process heat. The technology program is supplemented by a small assessment effort directed toward a better understanding of the potential applications and benefits of HTGRs.

With regard to the assessment work, emphasis will be placed on determining whether the HTGR could provide national benefits from the viewpoint of being able to reduce oil and gas imports while reducing both process wastes and environmental emissions. An additional effort will be placed on determining the safety and commercial risks of HTGRs relative to other reactors. Integrated with the above will be a study of small modular HTGRs to see if their safety, reliability, and economic features can have a significant impact on HTGR applications.

The HTGR technology development program at ORNL makes use of our unique facilities and capabilities. Thus, the planned program will place increasing emphasis on component development and testing and will emphasize the Component Flow Test Loop for (1) the Core Support Performance Test, (2) testing of the core auxiliary heat exchangers, (3) intermediate heat-exchanger development, (4) reformer testing, and (5) materials testing in general. These tests will require substantial expenditures for capital equipment. Other important testing will include pressure vessel testing, ceramic support testing, and development and testing of cladding and welding technology for the heat exchanger and other components.

Further, emphasis will be continued on fuels and materials technology development and will include the use and development of unique experimental facilities at ORNL (such as irradiation facilities and postirradiation examination facilities and equipment). Work in other important areas will be performed, including fission product behavior studies and reactor physics and shielding analyses (the latter work makes use of the Tower Shielding Facility, another unique facility) to determine reactor technical and economic performance.

Budgeting support for the national HTGR program remains uncertain. The ratio of studies and evaluations to experimental work would increase if the ORNL HTGR budget were to shrink; with an expanding budget, more emphasis would be placed on component and systems development and testing. Close cooperation with Gas-Cooled Reactor Associates (GCRA) (the national program coordinator) and General Atomic Company (GAC) (the national vendor) will continue; in particular, ORNL and GAC will jointly formulate technology development plans in the specific areas identified above.

An overview will be maintained of national and international HTGR development, including HTGR fuel recycle, so that ORNL can comment knowledgeably on program work. ORNL can also serve as technical aide to DOE and can provide technology transfer through interaction with industrial groups such as GCRA, GAC, and General Electric.

### *Commercial Nuclear Waste Management (AP, AH, AG)*

The ORNL commercial nuclear waste management effort comprises a variety of activities under categories AP, AH, and AG. These activities include developing technologies for immobilizing high-level and transuranic wastes, disposing of them in a geologic waste repository, cleaning up Three Mile Island wastes, treating uranium mill tailings, determining logistics for transporting wastes, and determining how best to dispose of surplus facilities and formerly used sites.

Personnel dedicated to this effort for FY 1982 total 25 full-time equivalents (FTEs); however, it is expected that there will be a slight decrease in funding in following years.

The Savannah River program for developing methods of solidifying high-level wastes is being closed out during FY 1982 because ORNL processes (sol-gel process, coated particles, and FUETAP* concrete) were not selected for large-scale development. In general, commercial waste funding has decreased as less generic R&D is supported in favor of site-specific work and demonstration projects. However, a number of programs, such as the immobilization of $^{14}C$ from the treatment of airborne activity and the use of FUETAP concrete for Transuranium Processing

*Formed under elevated temperature and pressure.

Facility wastes, have been identified as being possible replacements for those reduced or terminated.

### *Light Water Reactor Safety and Technology*

Support by DOE for this effort (Program AG) has never been large and is now reduced to partial funding for the Nuclear Safety Journal published by the ORNL Nuclear Safety Information Center. We continue to participate in working groups established by DOE to formulate program plans for LWR safety research to be submitted to Congress in response to Public Law 96-567. In concert with ORNL-Nuclear Regulatory Commission (NRC) programs, a new initiative for comprehensive investigation of the effects of plant aging on safety and reliability will be undertaken. In addition to this initiative, ORNL is anticipated to have a medium role in activities associated with source term determinations, instrumentation and controls, engineering simulator development, and advanced fuel concepts.

### *Space Nuclear Systems*

The Laboratory's role in this program has included characterizing, evaluating, and developing improved materials for use in space missions and in terrestrial applications utilizing isotopic power systems. Our principal efforts are focused on materials for fuel cladding and low-density structures and thermal insulation. Materials developed and fabricated by ORNL will be used in the Galileo and Solar Polar space missions. The total effort may decline after FY 1983 unless proposed missions beyond FY 1986 are approved.

An agreement between DOE, the National Aeronautics and Space Administration, and the Department of Defense (DOD) is being negotiated for the development and demonstration of a fission reactor system for space applications. The extensive use of ORNL expertise in compact reactor design, fuels and materials development, shielding design, and controls development is anticipated over the next five years.

### *Nuclear Energy Assessment*

Tasks in this area include economic, technical, and environmental assessments of the ability of nuclear power plants and their alternatives to supply electricity and heat. A continuing data base has been developed that characterizes the various nuclear power plant options and fuel cycles. Continuing studies are expected to focus on intermediate-term problems of LWRs. Topics to be investigated include the economics of nuclear power vs coal and the relative risks from electricity generating plants.

Activities in the field of cogeneration/district heating and programs on energy centers are being completed. Continuing studies will focus on small reactors for utility or cogeneration use or for small nations where large reactors are not practical.

## Assistant Secretary for Conservation and Renewable Energy

Since October 1981, ORNL has consolidated into a single Laboratory program all activities in energy conservation and in renewable sources of energy, including biomass, solar, wind, and geothermal. Most of the funding for this program derives from the Assistant Secretary for Conservation and Renewable Energy (Table 4).

### *Conservation (AK, AL, EC, ED, EE, EF, EG)*

The conservation program includes experimental research and development, analytical research, and a substantial number of related subcontracts. Many of the projects are undergoing extensive changes in response to the policy goals of the Reagan Administration. Only those elements of the program that can be described as long-range, high-risk, generic research are being retained; elements related to commercialization or implementation of technologies are being brought to an appropriate point for termination.

**Table 4. Program funding support from the Assistant Secretary for Conservation and Renewable Energy**

Millions of dollars—BA

| | FY 1982 | FY 1983 | FY 1984 |
|---|---|---|---|
| **AK—Electric Energy Systems** | | | |
| Total operating | 3.8 | 2.7 | 3.1 |
| Capital equipment | 0.1 | 0.2 | 0.2 |
| **AL—Energy Storage Systems** | | | |
| Total operating | 1.5 | 0.1 | 0.9 |
| Capital equipment | 0.1 | 0.0 | 0.1 |
| **EB—Solar Energy** | | | |
| Total operating | 5.0 | 0.8 | 2.0 |
| Capital equipment | 0.2 | 0.0 | 0.1 |
| **EC—Buildings and Community Systems** | | | |
| Total operating | 13.0 | 9.9 | 9.8 |
| Capital equipment | 0.1 | 0.5 | 0.7 |
| **ED—Industrial** | | | |
| Total operating | 1.8 | 1.3 | 0.8 |
| **EG—Multisector** | | | |
| Total operating | 1.0 | 1.4 | 1.1 |
| Capital equipment | 0.1 | 0.0 | 0.1 |
| **Miscellaneous (AM, CE, EE, EF)** | | | |
| Total operating | 1.6 | 1.7 | 1.5 |
| Capital equipment | 0.0 | 0.1 | 0.1 |
| **Total—Assistant Secretary for Conservation and Renewable Energy** | | | |
| Total operating | 27.5 | 17.8 | 19.3 |
| Capital equipment | 0.6 | 0.8 | 1.2 |

Program planning for the next several years is subject to great uncertainty because of the obvious intent to reduce budgets and terminate most research in this area. Nevertheless, we remain convinced that increased efficiency is an essential element in solving energy problems and that there is a role for government-sponsored research.

During FY 1982, the staff level for the ORNL conservation program was 91 FTEs, and the expenditure was $26 million. Our projections indicate a gradual decrease in staff during FY 1983. In subsequent years the levels may be further reduced.

Previously, the Building Equipment Research Program has had the objective of initiating or accelerating the development and commercialization of components and appliances that are now commercially available. Future activities, limited to generic research, will include the following: the study of dynamic losses in heat pumps and heat-pump water heaters and the experimental investigation of refrigerators. (Potential improvements, such as capacity modulation, will be tested.) Nonazeotropic refrigerant mixtures will be analyzed. An exploration will be made of methods for achieving high-efficiency thermal comfort through improved distribution systems. Testing will be continued on well-water and ground-source heat pumps. Advanced heat-pump concepts, including absorption and Stirling cycles, will be tested and evaluated. We will seek to transfer promising technologies to the private sector as the proof-of-principle is demonstrated. Under DOD sponsorship we are applying our knowledge of heat pumps to naval shipboard technology.

The 50,000-gpd ANFLOW (anaerobic packed-bed bioreactor) pilot plant has given good results during its first several months of operation. Effluent quality exceeded EPA secondary treatment requirements, and methane effluent concentration has exceeded 70%. Additional funding has been received from the EPA to extend the operation through the winter of 1982/1983. The 18-month operation, together with supporting research at ORNL, should permit consulting firms and municipalities to assess the advantages of this concept. We also hope to find support for investigating the application of the ANFLOW concept to industrial waste streams.

Research, evaluation, and regulatory support in the Residential Conservation Service retrofit program will continue into FY 1983. Revised regulations for residences and implementation of legislation covering commercial and apartment buildings have extended the time for completion of this project. A substantial program in buildings energy science will continue at near-current levels for the next several years. As testing of insulation materials is completed, the emphasis will shift to the design and construction of building systems (e.g., heterogeneous wall and roof sections) and to energy-flow diagnostic methods. An important component of this program will be the transfer of research results to diverse user communities.

We are continuing technical assistance to the Office of Industrial Programs with regard to the

materials requirements of various high-temperature, waste-heat-recovery projects. During FY 1982, we completed an analysis of opportunities for cogeneration. Recently, Headquarters has assigned ORNL a program of research on absorption and other chemical heat pumps for industrial waste heat applications.

Data analysis and forecasting for the Office of Vehicle and Engines R&D are continuing at a reduced level. In FY 1982, we started work on a closely related project for the Department of Transportation in which we are developing a methodology for estimating vehicular travel by 13 vehicle types for 12 highway categories. We will perform additional research projects for DOE on the development of high-temperature materials for advanced heat engines. We also anticipate that we will participate in planning for heavy-duty-transport research.

Energy demand modeling and program evaluation are activities in which ORNL has taken a leading role for a number of years. We are supporting the Office of State and Local Programs with evaluation of specific conservation programs. Prospects for continuation of this work under DOE sponsorship in future years are uncertain. However, we have identified other organizations with an interest in our analysis capabilities. In FY 1982 we performed work on energy demand and evaluation for the Tennessee Valley Authority (TVA), the Bonneyville Power Administration, the Electric Power Research Institute (EPRI), and Mathtech, Inc. Some of these efforts are expected to continue for the next several years.

ORNL manages a substantial portion of the programs of the Division of Electric Energy Systems. We will continue this assignment during the planning period. However, we expect the funding to decrease somewhat. Further development of load management systems will be left to the private sector. Research will continue on selected projects for the integration of new technologies into the power transmission grid, and R&D will also be needed on gaseous dielectrics, high-voltage ac and dc transmission, and electric substation equipment.

Our lead mission assignment in thermal energy storage will continue. Research will concentrate on advanced concepts such as phase-change materials and configurations that take advantage of thermal stratification in liquid storage systems. During FY 1982, we assumed responsibility for the mechanical-energy storage program. The current program is concerned with the development of flywheel rotors and subsystems for automotive applications, the study of alternative mechanical systems for automotive applications, and the study of other possible applications.

Experimental work has been initiated on several topics in the materials project of the Energy Conversion and Utilization Program. In FY 1982, the principal research areas were tribology, high-temperature materials, and polymers and plastics. Our assessment of materials technology indicates that efficiencies of most energy-using processes are limited by materials considerations. We hope to develop this project into one of more comprehensive scope.

Two conservation projects were terminated in FY 1982. These were analytical support for the Office of Program Planning and Evaluation and district heating studies.

## *Solar Energy (EB)*

The solar energy program at ORNL focuses primarily on laboratory and field studies of biomass production, on biotechnology, and on photovoltaics. A project on integration of wind energy conversion systems into the electrical grid is conducted in close coordination with work for the Division of Electric Energy Systems. Our effort in the solar energy program is expected to decline in future years as DOE cuts its funding of solar research.

The Short Rotation Woody Crops Program, managed by ORNL for the Biomass Energy Technology Division, consists of basic R&D in the areas of production and harvesting techniques. Twenty universities, two U.S. Department of Agriculture laboratories, a public utility, and three consulting organizations currently participate under ORNL management. The major activities of the program are species selection, stand management, and economic studies. First-generation genetic selection studies have demonstrated a 75% increase in productivity. Stand management tests are showing similarly large improvements from optimal irrigation, fertilization, spacing, and weed control. A closely related research project is an investigation of the environmental effects of total biomass removal. This work is being carried

out at ORNL and by subcontractors at five other sites. Preliminary results indicate high nutrient depletion by slash-pine and loblolly pine and fairly high depletion at the Oak Ridge site of calcium and possibly nitrogen.

ORNL continues to assist DOE in the technical monitoring and evaluation of photovoltaic demonstration projects. These include facilities at Georgetown University and at Mississippi County Community College. The project will terminate in FY 1983 with completion of the facilities. The new ORNL facility for studying atmospheric contamination effects on photovoltaic cells is nearly complete; studies will begin in FY 1983. Under sponsorship of the Solar Energy Research Institute we are studying (1) the use of lasers and ion implantation in photovoltaic cell manufacture and (2) the light-induced splitting of water using extracted green plant matter (chloroplasts). A companion study at ORNL on water splitting using live algae is sponsored by the Gas Research Institute.

A number of solar projects were completed or terminated during FY 1982. These include environmental assessments of alcohol fuels, fertility and tilth effects of fuel crop residue removal, assessment of biomass as a source of chemicals, agricultural and industrial process heating, assessment of decentralized solar technology, and development of passive solar heating techniques.

### *Geothermal Energy (AM)*

Our research in geothermal energy has concentrated on the development of high-efficiency heat exchangers, the problems of heat rejection from power plants, and the preparation of environmental statements and analyses. We anticipate that the activities in this program will be decreasing in future years.

Currently, we are studying heat-transfer and power-conversion systems, placing emphasis on experimental and analytical work on heat rejection systems as the work relates to geothermal power plants and the direct use of geothermal heat. Our work is aimed toward scale-up and field demonstration of enhanced condensation heat-transfer technologies developed at ORNL and analysis of the problem of water resources and cooling. This will be followed by work focused on the technology assessment and research required for selecting advanced heat-rejection system components.

Environmental assessments work consists of preparing environmental assessments, environmental impact statements, and other environmental documentation for specific projects and facilities and assisting in developing and evaluating agency environmental policies associated with the DOE geothermal programs. This effort requires ORNL to issue and manage subcontracts with industry and consulting firms.

## Assistant Secretary for Fossil Energy

ORNL has conducted a significant program of research and development in fossil energy since 1974. Funding for this program from the Assistant Secretary for Fossil Energy (FE) reaches ORNL both directly and through Energy Technology Centers and Operations offices. A minor portion of the funding comes from non-DOE federal sources and from industry. Direct funding from FE is shown in Table 5.

### *Fossil Energy Overview (AA, AC, CG, CH)*

The Laboratory has given coal-related work a high priority, and its Fossil Energy Program offers the opportunity to integrate some elements of the work being carried out for the various parts of DOE as well as for other federal organizations. About 4% of the Laboratory's effort is conducted on behalf of FE. Although our program grew through FY 1981, a decrease of about 25% in actual dollars available occurred in 1982 (see Table 6), and the preliminary indications are that the spending in FY 1983 may decrease by as much as an additional 10%.* The in-house staffing level decreased from 116 in FY 1981 to 94 in FY 1982 and will decrease to less than 75 in FY 1983. Because the emerging goals of the national fossil energy effort are now more closely aligned with ORNL capabilities, there is reason to expect at least a partial recovery of previous support. The major objective of the ORNL Fossil Energy Program is that of solving fundamental problems that

*Erosion of funding available as a result of inflation is in addition to the funding spending levels indicated.

**Table 5. Program funding support from the Assistant Secretary for Fossil Energy[a]**

Millions of dollars—BA

| | FY 1982 | FY 1983 | FY 1984 |
|---|---|---|---|
| **AA—Coal** | | | |
| Total operating | 11.3 | 8.5 | 16.8 |
| Capital equipment | 0.2 | 0.0 | 1.0 |
| **Miscellaneous (AC, CG, CH)** | | | |
| Total operating | 0.4 | 0.2 | 0.2 |
| **Total—Assistant Secretary for Fossil Energy** | | | |
| Total operating[b] | 11.7 | 8.8 | 17.0 |
| Capital equipment | 0.2 | 0.0 | 1.0 |

[a]Includes only funding provided directly in the ORNL financial plan; substantial fossil energy funding from DOE's Oak Ridge Operations office is excluded.

[b]Because of planned expenditure of carry-over funds, the actual program level at ORNL is not accurately reflected by projected allocations of new funds. Planned expenditures: FY 1982, $13.3 million; FY 1983, $12.1 million; FY 1984, $15.8 million.

private industry is not motivated to invest in, though an R&D payoff for the country can be perceived. Some specific areas in which work is being conducted are environmental control technology, mitigation of health effects, materials, components, process technology, liquefaction, combustion, process instrumentation, surface coal gasification, enhanced oil recovery, and fossil energy information. Our work in several of these areas is done in cooperation with DOE Energy Technology centers, and some of the funding provided by FE comes to ORNL through these centers.

Our role in fossil energy research has involved extensive interaction with industry and offers the opportunity for substantial cooperative efforts with individual companies working in the field.

## *Advanced Environmental Control Technology (AA 05)*

This area involves the development and evaluation of technology for dealing with gaseous, liquid, and solid effluents from the direct utilization of fossil fuels and from fossil fuel conversion processes. Current efforts are in the characterization of coal-derived solid wastes and in the chemistry and treatment of waste liquids.

This funding area now also includes development of coal preparation technology—a field in which ORNL has demonstrated substantial achievements in magnetic beneficiation of dry coal using high-gradient magnetic separation (HGMS) and open-gradient mag-

**Table 6. Spending by ORNL for the Office of Fossil Energy[a]**

| | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 |
|---|---|---|---|---|---|---|---|---|---|---|
| Process technology | 0.4 | 0.7 | 1.3 | 1.9 | 1.6 | 1.5 | 1.9 | 2.5 | 2.2 | 1.2 |
| Studies and evaluations | 0.1 | 0.4 | 1.3 | 2.8 | 3.8 | 3.7 | 3.5 | 5.0 | 2.4 | 2.4 |
| Combustion | | | 1.0 | 1.7 | 1.1 | 1.2 | 1.4 | 2.4 | 1.6 | 0.2 |
| Environmental impacts | | | | 0.8 | 1.0 | 1.6 | 2.3 | 3.1 | 1.9 | 2.5 |
| Materials | | | 0.2 | 0.6 | 0.6 | 1.2 | 4.9[b] | 6.7[b] | 5.5[b] | 7.2[b] |
| Components | | | | | | | | 0.1 | 0.9 | 0.3 |
| Total expenditures | 0.5 | 1.1 | 3.8 | 7.8[c] | 8.1 | 9.2 | 14.0 | 19.8 | 14.7 | 13.8 |
| Total in-house expenditures | 0.5 | 1.1 | 3.8 | 7.2 | 6.4 | 6.7 | 9.3 | 12.5 | 10.5 | 9.3 |
| Total in-house direct personnel | 5.0 | 11.7 | 30.0 | 70.0 | 68.0 | 70.0 | 88.0 | 116.4 | 94.0 | 71.7 |

[a]Expenditure levels in millions of dollars are given by fiscal year and activity area. Support for these include funds received indirectly through operations offices and the Energy Technology Centers as well as through funding in ORNL's own financial plan and exclude funding for activities not included in the ORNL fossil energy programs.

[b]Includes major subcontract costs ($2.2 million in FY 1982) for the national Fossil Energy Materials Program, but not funds ($1.5 million in FY 1982) for ORNL-managed work at other national laboratories.

[c]Total does not equal sum of activity areas because of rounding errors.

netic separation. While ORNL currently has no work in this area for the FE, it remains an area where substantial economic and resource conservation gains could eventually result from R&D activities and is an area of interest to TVA. Development and design efforts supported by TVA are continuing and are directed toward an HGMS pilot plant for TVA's Paradise, Kentucky, site. In addition, some modeling of coal preparation plants is being carried out with TVA funding.

Environmental acceptability to workers in the field, as well as to the general public, and the use and disposition of water are two fundamental and long-term problems confronting the expanding coal industry. FE has identified the development of improved coal conversion worker health and occupational safety concepts as an important component of the FY 1983 Fossil Energy Program. ORNL experience at several operating facilities (University of Minnesota–Duluth, Community Area New Development Organization, and H-Coal) confirms the importance of this activity. An integrated program of research and development in worker protection (as applied to compliance-oriented measurements) is needed. ORNL plans to expand its work in this area and proposes to become a center for the coal conversion worker protection programs conducted by DOE. A substantial program is under way and is expected to continue at ORNL in examining the biological activities of coal liquids and the effects of potential product upgrading processes on that activity. Work on environmental control technology (ECT) is focused on aqueous wastes associated with coal conversion facilities and draws on work previously supported by the Assistant Secretary for Environmental Protection, Safety, and Emergency Preparedness. This work is directed toward a transportable process development unit that could be operated at various experimental coal conversion facilities to expand the base technology for wastewater treatment. Although all of the above areas are closely interrelated technically, support for the work comes from a number of subprogram areas including AA 15, AA 25, and AA 85.

## *Advanced Research and Technology Development (AA 15)*

The Advanced Research and Technology Development AR&TD program for DOE encompasses a broad spectrum of long-range activities including R&D in chemistry, materials, components, and process technology for gasification, liquefaction, and direct utilization concepts, as well as engineering and systems analysis work and some effort on ECT. Modeling of fossil fuel supply sources is also included. Current major components of this work are the management by ORNL and Oak Ridge Operations (ORO) of the AR&TD Fossil Energy Materials Program as a lead laboratory assignment and the comprehensive analyses of liquefaction technologies. The overall objective of the AR&TD Fossil Energy Materials Program is to conduct a long-range basic research and development program that addresses in a generic way the materials needs of fossil energy systems and ensures the development of advanced materials and processing techniques. The technology assessment effort includes both direct and indirect liquefaction areas and considers the associated ECT as well as the conversion processes.

ORNL hopes to expand its work on components technology and to continue to establish interrelationships between component design, analysis, and materials development. Increased support will also be sought for a generic ECT effort that addresses the needs of coal liquefaction, gasification, and shale oil wastewater treatment.

## *Liquefaction (AA 25)*

ORNL activities in the coal liquefaction area emphasize direct liquefaction through studies on coal conversion chemistry and measurement of physical properties of representative coal-derived liquids and slurries under process conditions. ORNL plans to sustain an important program of research, development, and evaluation in direct and, to a lesser extent, indirect liquefaction involving chemistry, process

engineering, components, materials, and environmental and health aspects.

### *Combustion Systems (AA 35)*

Efforts in combustion systems are focused on fluidized-bed combustion (FBC) processes for coal [both atmospheric (AFBC) and pressurized (PFBC)] and on the study of systems utilizing the unique advantages of FBCs in an optimal fashion, including the assessment of equipment. However, the level of effort supported by FE on AFBC is being severely curtailed, and we expect to do little R&D in this area in the near future. We anticipate that some analysis work on PFBC systems will continue.

In the utility area, we have provided substantial technical support to TVA in the design of a 20-MW(e) AFBC pilot plant. The Laboratory's participation in the TVA pilot plant and ORNL's past involvement offer a significant opportunity for R&D funded by FE on coal feed systems, components, materials, reaction engineering, and AFBC systems modeling.

### *Heat Engines and Heat Recovery (AA 55)*

Work in this area addresses the recovery and utilization of heat energy at low and high temperatures. Support for the associated ORNL work is to be transferred to the Assistant Secretary for Nuclear Energy, and no significant effort is anticipated under this heading beyond FY 1982.

### *Mines R&D (AA 75)*

Support previously provided by FE for coal mining activities has been transferred to the Department of the Interior, and coal preparation work is now funded under AA 05 (Advanced Environmental Control Technology). Hence, no ORNL involvement in this area is anticipated.

### *Surface Coal Gasification (AA 85)*

Until recently, ORNL's involvement in this area has emphasized environmental considerations and evaluation of gasification in indirect liquefaction processes. However, in FY 1982 substantial work was begun in relation to both materials and components for gasification systems. ORNL will continue to provide technical management for the materials work under the ORO/ORNL lead role in Fossil Energy Materials and will contribute to the assessment and development of component technology. Work is also continuing in the areas of environmental and health effects and wastewater treatment.

### *Enhanced Oil Recovery (AC 15)*

ORNL's effort in this area is currently small and is directed toward the study of amphiphilic compounds in enhanced oil recovery. This work is expected to continue in the short term, but the long-term effort is dependent on the future program at Bartlesville Energy Technology Center through which the program is managed.

### *Oil Shale (AC 20)*

ORNL's involvement in an eastern shale program is consistent with current expertise and regional interests. No activities are currently funded by FE, but work has been proposed for technological development in oil recovery, metal resource recovery, environmental impact assessment and control, and waste management.

### *Summary*

Through work that began in 1974, ORNL has developed a strong expertise in the fossil energy area and has accumulated a number of unique and important research and development facilities. Since FY 1981, an annual 10 to 25% decline in spending has been experienced (see Fig. 8). Inflation has further reduced the ORNL in-house direct staff level from 116 in FY 1981 to 94 in FY 1982 and to an estimated level of 72 in FY 1983. We must also allow for a possible decline in the funding that comes to us through the Energy Technology centers as they, responding to similar budget pressures, must make decisions on dividing their funds between internal activities, national laboratories, and external subcontracts. We are concerned that, unless the course is altered, we will lose a number of important program elements and that our ability to conduct strong R&D projects for FE will be compromised seriously.

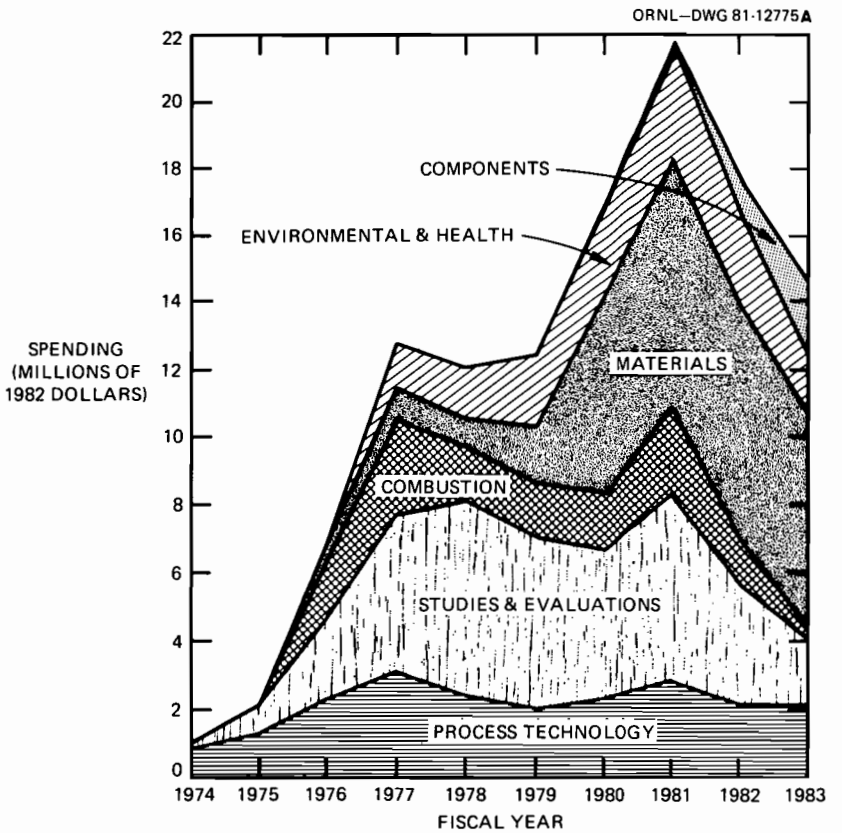


*Fig. 8. ORNL support from the Assistant Secretary for Fossil Energy (adjusted for inflation).*

## Assistant Secretary for Defense Programs

The Laboratory's major effort for the Assistant Secretary for Defense programs is its program on defense nuclear waste management. Smaller, but important, efforts are devoted to our $^{233}U$ Program and to nuclear material security and safeguards research (Table 7).

### *Defense Nuclear Waste Management (AR)*

The ORNL defense nuclear waste management effort includes two categories of work: management of wastes generated at ORNL and development of technology in areas of ORNL expertise. The total FY 1982 effort under category AR is 122 FTEs.

The ORNL Waste Management Operations Program supports the operations, process development, and engineering efforts required for successful man-

**Table 7. Program funding support from the Assistant Secretary for Defense**

Millions of dollars—BA

| | FY 1982 | FY 1983 | FY 1984 |
|---|---|---|---|
| **AR—Defense Waste Management** | | | |
| Total operating | 15.7 | 18.1 | 19.2 |
| Capital equipment | 0.5 | 1.3 | 1.5 |
| Construction | 7.8 | 5.0 | 4.0 |
| Proposed construction | 0.0 | 2.0 | 5.8 |
| **GE—Materials Production** | | | |
| Total operating | 5.2 | 5.6 | 4.3 |
| Capital equipment | 0.1 | 0.1 | 0.1 |
| **Miscellaneous (GB, GC, GD)** | | | |
| Total operating | 0.3 | 0.3 | 0.3 |
| Capital equipment | 3.1 | 2.2 | 2.2 |
| **Total—Assistant Secretary for Defense** | | | |
| Total operating | 21.3 | 24.0 | 23.9 |
| Capital equipment | 0.6 | 1.4 | 1.7 |
| Construction | 10.9 | 7.2 | 6.2 |
| Proposed construction | 0.0 | 2.0 | 5.8 |

agement of ORNL-produced radioactive wastes—both wastes being generated currently and those generated by previous programs dating back to 1943. The program's long-term objective is to ensure that new technology and improved facilities will enable compliance with future regulations. Many of ORNL's waste management facilities were constructed in the 1940s and early 1950s and are now being extensively improved. Projects that have been completed—costing a total of $20 million—include the Process Waste Treatment Plant, Intermediate-Level Waste Facility modifications, and the New Hydrofracture Facility. Construction for the Gunite Tank Sludge Removal Project has been completed; initial disposal of sludge using the New Hydrofracture Facility started during the summer of 1982. The Radioactive Waste Facilities Improvements Project, which includes a central Waste Operations Control Center, is now under construction. Plans also include the expenditure of considerable general plant projects funds for facility improvements. Decontamination and decommissioning will become an increasingly important part of the future effort.

In the category of waste management technology, ORNL supports each of the major programs sponsored by DOE, particularly as associate lead for technological development in the National Low-Level Waste Management Program. ORNL also has a lead role for preparation of a DOE-integrated data base for national waste management planning and analysis. Concrete waste form development, including grout development for the New Hydrofracture Facility, is a major area of ORNL expertise and is an important component of our nuclear waste programs. ORNL now has the only operational differential dieaway neutron interrogation waste drum analysis system in the DOE organization. This device, based on a Los Alamos National Laboratory development, will be used to establish whether a waste drum has transuranic content that requires expensive retrievable storage or whether the drum should be classified as low-level waste and disposed of by less expensive shallow land burial. Another area of ORNL expertise is in radioluminescent lights development, an important component in DOE's By-products Utilization Management Program.

The defense nuclear waste budgets for future years appear relatively stable. The staff continues to work with each nuclear waste program to ensure that ORNL expertise is used where it is most needed.

## $^{233}U$ Program (GE 03)

The ORNL $^{233}U$ Program encompasses two tasks. The first is routine operation of the $^{233}U$ National Repository that supplies various experimenters in the United States and abroad with $^{233}U$ (as directed by DOE through ORO) and recovers $^{233}U$ from scrap generated by these experimenters. The second is the installation and operation of a facility capable of converting 1000 kg of uranium from a liquid to an inert solid, which would ameliorate a potentially hazardous situation. This work is being carried out under the auspices of the Consolidated Edison Uranium Solidification Program (CEUSP).

The effort for repository operation is expected to remain at a low level during the next five years. Although the demand for $^{233}U$ is expected to decrease slightly, it should remain at several kilograms per year. The bulk of the funding for this task is expended for equipment replacement and maintenance, safeguards, and accountability; the facility uses aging components that were installed as part of the Thorex Pilot Plant in 1954.

The objective of CEUSP is to design and install, in an existing process cell, equipment that will enable conversion of the uranium to a solid beginning in FY 1985. The schedule for this program has slipped to some extent, and the funding requirements have increased because of the complexity of the mechanical equipment and the limited cell space into which the equipment must be installed. The major engineering effort occurred in FY 1980 and FY 1981 and has continued through FY 1982, with a smaller but still substantial effort required through FY 1985. Major installation will occur in FY 1982 and FY 1983, and completion, in FY 1985. Facility operation will start shortly thereafter, and completion of the task is scheduled for FY 1987.

Previous plans to recover 306 kg of $^{233}U$ by reprocessing excess Light Water Breeder Reactor fuel rods have been changed. The revised plan is to provide retrievable storage for these 15,000 unirradiated fuel rods at another DOE facility. They will be available for processing when a need for the $^{233}U$ arises.

### *Nuclear Materials Security and Safeguards*

In the Laboratory's single task included in this activity, we are developing improved methodology for isotopic analysis, which is the foundation of nuclear safeguards. Ongoing R&D is being carried out to improve the mass spectrometric isotopic analyses of elements of interest to safeguards (i.e., U, Pu, and Th). Applications of various analytical techniques are being explored to verify inventories of nuclear materials by employing improved mass measurements that can furnish tank volume calibrations as well as total fissile inventory. A quadrupole mass spectrometer and associated equipment for use as an onsite analytical system have been fully evaluated in the field and been shown to be fully capable of providing analyses sufficient to meet safeguards requirements. Transfer of the technology to other installations will be effected at the request of the Office of Safeguards and Security. We will continue to evaluate the microtechniques as an archival storage device and to explore the application of resin-bead technology to the full fuel cycle.

## Assistant Secretary for Environmental Protection, Safety, and Emergency Preparedness

ORNL's work for the Assistant Secretary for Environmental Protection, Safety, and Emergency Preparedness (EPSEP) falls primarily within DOE's program of environmental research and development. A small effort is devoted to several other DOE program areas under EPSEP's responsibility. ORNL's total funding from EPSEP amounts to about 2% of the Laboratory's total operating budget (Table 8).

**Table 8. Program funding support from the Assistant Secretary for Environmental Protection, Safety, and Emergency Preparedness**

Millions of dollars—BA

| | FY 1982 | FY 1983 | FY 1984 |
|---|---|---|---|
| **Total—Assistant Secretary for Environmental Protection, Safety, and Emergency Preparedness (EF, HA, SA, UB, UE)** | | | |
| Total operating | 5.9 | 4.1 | 4.1 |
| Capital equipment | 0.0 | 0.3 | 0.2 |

### *Overview and Assessment (HA 01)*

The ORNL programs funded by EPSEP are designated "overview and assessment" by DOE and cover many facets of environmental monitoring, research, and regulatory compliance.

The largest component is the Remedial Action Survey and Certification Activity (RASCA) Program. The RASCA Program will continue to perform radiological surveys at sites formerly used under contract with the Manhattan Engineer District (MED) and the Atomic Energy Commission (AEC), at inactive uranium mill sites located at surplus DOE sites owned by the U.S. government, and at private properties in the vicinity of these sites. The majority of the RASCA surveys to be performed in the next few years are for private properties located in Grand Junction, Rifle, and Durango, Colorado. After completion of the needed remedial actions by other organizations, postremedial action (PRA) audits are performed by ORNL. Most of the PRA audits of the MED/AEC sites take place in the eastern United States, primarily the Northeast. These audits are scheduled for completion during FY 1982 to FY 1990. Audits for the vicinity properties will be scheduled as the remedial actions are carried out.

Another well-established program is the Environmental Impacts Program (EIP). The EIP will continue to provide technical support to EPSEP's Environmental Compliance Division, which has the responsibility of ensuring that all DOE activities are in compliance with the National Environmental Policy Act (NEPA) of 1969 and other environmental laws and regulations. Since 1971 EIP staff has been involved with preparing environmental assessments (EAs) and environmental impact statements (EISs) on a variety of projects including nuclear power plants; enhanced oil recovery; conservation; solar (photovoltaic and biomass) energy; geothermal energy; coal gasification and liquefaction projects; uranium mining, milling, and enrichment; fusion; and waste isolation; and on legislation such as the Fuel Use Act and the National Energy Plan. The EIP staff will continue to prepare EISs, EAs, and technical and scientific issue analyses

as required; will analyze EISs and EAs prepared by other federal agencies; and will prepare guidelines on complying with state and federal environmental permits and approvals. A potential growth area is that related to environmental analysis of DOE's nuclear and defense programs.

A significant ORNL program is devoted to the evaluation of environmental control technologies for coal conversion processes. Work began in 1979 to construct and test a 1-gal/min (gpm) wastewater treatment process development unit (PDU). The control technologies currently being investigated are carbon adsorption, ozonation, and reverse osmosis. The operating PDU will allow development of advanced wastewater treatment techniques needed to achieve total recycle or to meet possible future discharge regulations such as zero stream discharge, to provide scale-up data for larger treatment plants, and to assist in solving operational problems on the existing wastewater treatment facility. The process technology for the reduction of bioactivity in the products of direct coal liquefaction will be assessed to suggest possible directions for the further development of such technology and to make preliminary estimates of the cost of bioactivity reduction by various methods now available or potentially developable.

ORNL will continue to assist EPSEP in the development of environmental assessment methodologies; the development of environmental, economic, and energy data bases; and the analysis of important energy and environmental issues such as air quality, acid deposition, and water resource impacts. We will assist EPSEP in its planning and preparedness for environmental protection and public safety. This includes assistance to DOE in implementing its supporting responsibilities to other federal, state, and local agencies in radiological emergencies. One problem being studied is the development of procedures, equipment, and techniques for decontamination and emergency operation in contaminated environments. ORNL is applying expertise in regional analysis, transportation, and economics for evaluating the regional effects of energy emergencies such as oil shortages and the consequences of various mitigating measures. To provide input to DOE planning in the area of electric utility system emergency preparedness, studies of utility-coordinated planning and operation and powerplant productivity are under way. Future work may involve assistance to the Strategic Petroleum Reserve in developing disbursement plans and the Crude Oil Programming System.

Illustrative of ORNL's cooperative work with foreign countries is the provision of technical advice and equipment to the Junta de Energia Nuclear in Spain for measuring radioactivities in environmental samples such as food products, soil, and air. Assistance provided will allow for increased counting capacity of samples containing $^{239}Pu$ by alpha spectrometry and of samples containing $^{241}Am$ by a rapid, accurate, and inexpensive technique.

## Energy Information Administration (TA, TB, TC, TD)

ORNL conducts an important program that has grown significantly over the last couple of years for DOE's Energy Information Administration (EIA). A substantial amount of subcontracting is associated with this work, but funding for internal operations has grown to a level that will support 23 direct FTEs during FY 1983 (Table 9).

**Table 9. Program funding support from the Energy Information Administration**

Millions of dollars—BA

| | FY 1982 | FY 1983 | FY 1984 |
|---|---|---|---|
| **Total—Energy Information Administration (TA, TB, TC, TD)** | | | |
| Total operating | 11.2 | 6.5 | 9.0 |
| Capital equipment | 0.0 | 0.1 | 0.1 |

To help meet the needs of energy policymakers for reliable and credible information, ORNL provides both research and management support for EIA. The work is pursued through a balanced application of resources from within and from outside the Laboratory. Multidisciplinary teams of involved participants are drawn from the Laboratory, the academic community, and the private sector to work on specific problems.

The ORNL program consists of evaluation, assembly, and analysis of data and information relevant to the production and use of energy in the United

States. Related statistical and economic research is also conducted. The program focuses on the adequacy of and requirements for information to meet national and regional/state analysis and planning needs. Support is provided to each EIA office that includes work in areas where the Laboratory has both interest and experience. Currently, the work includes analysis of present and future data needs, data validation, analysis and data validation techniques, development of rigorous and well-documented energy forecasting and policy analysis models and methods, and research on model evaluation techniques.

ORNL conducts a lead laboratory mission in data quality assessment. This mission includes the development and demonstration of techniques for improving data quality as well as techniques for improving the quality of data analysis. To date, ORNL research has contributed to innovative, flexible methods of data handling and storage, and analysis projects have produced definitive paradigms for data compilation as well as authoritative assessments of a variety of technical issues. Future work in support of this mission will include (1) continuation of broad technical support for EIA, (2) development of a more comprehensive range of data quality assessment tools, and (3) improved transfer of analytical methods.

## Other DOE Offices

A low level of assistance is provided to three other DOE offices. Work for these totals less than $1 million annually (Table 10).

**Table 10. Program funding support from other DOE offices**

Millions of dollars—BA

| | FY 1982 | FY 1983 | FY 1984 |
|---|---|---|---|
| **Total—Federal Energy Regulatory Commission (VI)** | | | |
| Total operating | 0.0 | 0.7 | 0.5 |
| **Total—Office of Policy, Planning, and Analysis (PE)** | | | |
| Total operating | 0.2 | 0.1 | 0.1 |
| **Total—Economic Regulatory Administration (UA, UB, UC)** | | | |
| Total operating | 0.0 | 0.1 | 0.0 |

### *Federal Energy Regulatory Commission*

Efforts for the Federal Energy Regulatory Commission (FERC) are very modest, but they are growing (Table 10). During FY 1982 a project was completed in which wheeling arrangements were reviewed. Future work may involve technical support to the Office of Electric Power Regulation in the area of NEPA compliance. In addition, various tasks are being performed for FERC under the auspices of the EIA.

### *Office of Policy, Planning, and Analysis*

Work for the Office of Policy, Planning, and Analysis is at a very modest level and is not expected to increase significantly (Table 10). It involves work on energy demand models and analyses that apply in the transportation and industrial sectors as well as work on an oil cartel model.

### *Economic Regulatory Administration*

Work for the Economic Regulatory Administration is decreasing and currently includes only work for the Office of Special Counsel on various topics ranging from the impacts of crude oil disruptions to examining crude oil price behavior over time. A low level of effort may continue.

# *Work for Others*

About 20% of ORNL's total operating budget is funded by agencies other than the DOE. The largest portion of this funding comes from NRC. However, when a DOE program interest exists and facilities are available, the Laboratory undertakes work for other federal agencies. The level of this effort is expected to remain approximately constant over the planning period (Table 11).

## Nuclear Regulatory Commission

NRC sponsors about 9% of the total work at ORNL. This level of effort has held steady for the past few years, although the specific breakdown of the work has changed significantly. The major thrust of the NRC work consists of reactor safety research

**Table 11. Program funding support from agencies other than DOE**

Millions of dollars—BA

| | FY 1982 | FY 1983 | FY 1984 |
|---|---|---|---|
| **Nuclear Regulatory Commission** | | | |
| Total operating | 30.6 | 29.0 | 30.2 |
| Capital equipment | 1.3 | 0.9 | 0.8 |
| **Environmental Protection Agency** | | | |
| Total operating | 6.1 | 5.8 | 5.1 |
| **Department of Health and Human Services** | | | |
| Total operating | 5.9 | 5.1 | 5.2 |
| **Department of Defense** | | | |
| Total operating | 4.0 | 4.9 | 4.6 |
| Capital equipment | 0.1 | 0.1 | 0.1 |
| **Other federal agencies** | | | |
| Total operating | 7.9 | 8.0 | 8.5 |
| **Nonfederal agencies** | | | |
| Total operating | 4.4 | 4.2 | 4.5 |

and analysis in areas in which ORNL has proven technical capabilities. These areas include structural analysis, materials evaluation, fission product behavior, accident sequence analysis, advanced instrumentation and diagnostics, human factors, reliability and operating data analysis, integrated risk assessment, and radiation dose and health effects.

The present NRC programs are changing significantly. With respect to NRC-established trends, experimental work concerned with the design basis loss-of-coolant accident has decreased significantly. Experimental work has increased in the areas of fission product release and transport and of pressurized thermal shock. In general, the number of research programs has grown, but the trend has been toward smaller, analytical programs. The overall level of NRC programs is expected to remain constant throughout the planning period. Technical concerns of NRC derived from experiences with operating nuclear reactors have given rise to many new and challenging programs at ORNL. This work includes the analyses of severe accident phenomena, operations and maintenance experience, man/machine interactions, fission product release and transport, core-melt phenomena, pressure vessel long-term behavior, and control systems and plant dynamics. A significant increase in emphasis on risk assessment and activities related to the analysis of operating data, including licensee event reports, has occurred in ORNL programs.

The future direction of NRC programs for the planning period is difficult to detail because of the lack of a well-established national plan for nuclear technology and because of the delays that currently exist in the nuclear reactor industry. However, ORNL is actively pursuing the development of programs concerned with the establishment of a quantifiable safety goal, reevaluation of siting criteria, aging effects in nuclear power plants, nuclear power plant standardization, and events leading to core melting. It is envisioned that ORNL will use its expertise to increase the acceptability of front-end fuel cycle activities. It is also envisioned that some of the ORNL expertise in waste management can be used in research related to long-term disposal of high-level and low-level wastes. ORNL will continue to support NRC as broadly as possible while avoiding any direct involvement in the licensing process.

## Other Agencies

### *Life Sciences Work*

Approximately 40% of the funding for our life sciences programs is provided by agencies other than DOE, primarily EPA, the Department of Health and Human Services (HHS), and the U.S. Army. The research conducted for the Army is discussed in a later section. Both DOE and non-DOE agencies benefit from the work done for other agencies because all the work is performed in the same general locations within laboratories where facilities, equipment, and staff may be shared. This close interaction among staff provides for a continuing exchange of scientific information.

**Environmental Protection Agency.** The percentage of funds provided by EPA for life sciences research at ORNL was 16% in FY 1981 and 12% in FY 1982. This downward trend may well continue. If federal appropriations to EPA are reduced, we will undoubtedly see further reductions in funds at ORNL.

Our work for EPA addresses numerous health and environmental problems and issues. In 1979 a deci-

sion by the Office of Management and Budget shifted much of this work from DOE to EPA. Our research focuses on the identification of the effects of pollutants associated with energy production processes, effluents, and disposal such as the effects of utility effluents on ecology, the extent of carcinogencity of diesel emissions, the toxicity of leachates of solid wastes, and the effects of acid precipitation on agricultural systems and forest soils. Much of the research involves methods development for risk analysis and determination of detriment or risk from potentially hazardous materials. Specialized data bases are developed such as the "Chemicals Identified in Human Biological Media" data base, and literature reviews and state-of-the-art documents are prepared on specific chemicals selected by EPA. Administrative management, coordination, and information support will continue to be provided to the EPA Gene-Tox Program to aid evaluation of mutagenicity bioassay systems.

**Department of Health and Human Services.** HHS is the third largest funder of life sciences research at ORNL and supports research in carcinogenesis, genetics, and toxicology. HHS funding is expected to remain constant over the next five years. The various branches of HHS supporting our work include the National Cancer Institute (NCI); the National Institute of Environmental Health Sciences; the National Heart, Lung and Blood Institute; the National Institute of General Medical Sciences; the Food and Drug Administration (FDA); the National Library of Medicine (NLM); and the National Toxicology Program (NTP). For FDA, NLM, and NTP, we are developing nationally and internationally available data bases in the areas of genetic, reproductive, and general toxicology.

For NCI, we are studying the mechanisms of viral-, chemical-, and uv radiation-induced carcinogenesis; cocarcinogenesis of ionizing (x-rays or neutrons) and uv radiation; and DNA repair mechanisms in carcinogenesis. Two organ systems that have been widely studied are the respiratory tract and the skin. Both organs represent major areas of exposure to chemicals and other potentially hazardous agents in the environment. We are performing chemical characterizations of smokes from experimental and commercial cigarettes, with particular interest in identifying bioactive constituents. We are also validating the lung tumor assay, which is a convenient short-term in vivo bioassay. Also, a standard protocol for determining the frequencies of chromosome aberrations and sister chromatid exchanges in human lymphocytes is being developed; this will allow for standardization of results and will make interlaboratory comparisons feasible.

**Other Support for Life Sciences.** Other agencies from which we receive support for life sciences research include the National Science Foundation (NSF), EPRI, TVA, the National Aeronautics and Space Administration, the Department of Agriculture, the National Oceanic and Atmospheric Administration, the Consumer Product Safety Commission, the National Research Council of Canada (NRCC), and several universities (e.g., Cornell, The University of Tennessee, and the University of Washington).

The NSF provides support for the Small-Angle Scattering Facility, the study of material spiralling in stream ecosystems, the study of the role of terrestrial ecosystems in the global carbon cycle, and for advanced studies in ecosystem theory. We are investigating the effects of acid rain on crops and other plants for EPRI.

For the NRCC we are evaluating devices for monitoring formaldehyde in residences. The objective of the project is to provide low-cost, sensitive, and reliable monitors for low-level measurements of formaldehyde.

Our work for the Consumer Product Safety Commission is expanding. We have been taking field measurements of a number of indoor air pollutants in residences in the Oak Ridge area. The pollutants of immediate interest are formaldehyde and other organic vapors emanating from consumer products and structural materials. Other pollutants to be studied are nitrogen dioxide, carbon monoxide, and particulate matter.

## *Department of Defense*

As part of its assistance to DOD, ORNL performs research for the Army, Navy, Air Force, and the Defense Nuclear Agency. Over the past, funding by these sponsors has amounted to a relatively small fraction of the Laboratory's total budget. However,

DOD is making increasing use of ORNL's research facilities. Although total DOD funding for FY 1982 amounted to $4 million, or only slightly more than 1% of the total Laboratory operating budget, FY 1982 funding on DOD programs at the Laboratory was up 33% over the levels of FY 1981. Efforts are under way to enhance and expand our working relationship with those branches of DOD that have energy-related R&D programs. Future funding in this area is expected to increase and eventually reach a few percent of ORNL's budget.

Broad technical areas in which ORNL could provide expanded support include power sources for directed-energy weapons, space nuclear power systems, and reactor and radiation shield designs for other power sources required by the military.

**Army.** The largest portion of DOD research at ORNL is performed for the Army. Funding for Army programs has increased from $1.6 million in FY 1981 to $2.7 million in FY 1982, with future increases expected. Our largest task for the Army is devoted to the physical, chemical, and toxicological characterization of chemicals (and their degradation products) of interest to the Army. Such chemicals include military obscurants, propellants, and shale- and petroleum-derived diesel fuel. In addition, we conduct research concerning the use of tritium for cockpit lighting and the nuclear hardening of materials. Our advisory support to the Tennessee Tombigbee Waterway Project continues. We have developed a numeric data base management system that has been used for four Army Corps of Engineers research programs and could be used for analyzing any aquatic or terrestrial site.

We have recently begun work on chemical structure-activity modeling using computational heuristic reasoning and on data validation and analysis for the U.S. Army Material Development and Readiness Command, and we are providing assistance to the Army Fuel Strategy Program. Future funding is expected for the development of algorithms and software for sparse matrix computations and for nuclear waste technology R&D.

**Navy.** ORNL's programs funded by the Navy fall largely into four separate tasks. The first is the development of a new generation of radiation detection and measurement instruments for use by the Navy's nuclear fleet and weapons-handling facilities. In the second task, single-atom detection techniques are being applied to the study of density fluctuation and diffusion phenomena at the level of a few atoms per cubic centimeter. In this work, an innovative test has been developed to verify the ergodic hypothesis of statistical mechanics. In a third project ORNL is attempting to determine the design parameters and predict the performance of heat pumps that would reduce the energy requirements of naval ships for space conditioning. Finally, a mathematical model has been designed for the Marine Corps that forecasts levels of repair/maintenance required to keep equipment (including vehicles) at peak performance. The validity of the model has been evaluated and repair facility personnel have been trained in its use.

There are several areas in which support to the Navy may expand. To provide the Navy with technical assistance in meeting the requirements of the NEPA of 1969, proposals have been submitted (1) to determine whether detectors containing various thermoluminescent materials can be made into routine personnel neutron dosimeters, (2) to use high-power pulsed tunable dye lasers to determine the electron-atom compound states for helium and beryllium negative ions, and (3) to assist in the analysis of maintenance and reliability of the Navy's financial and inventory accounting systems by estimating their dependability and suggesting methods for improvements.

**Air Force.** During the past year, funding from the Air Force increased. Recent work has consisted of a mix of applied research (e.g., using $^{85}Kr$ for airfield taxiway light fixtures and in more basic studies such as low-energy electron research). Funding was recently received to study the gas-cooled reactor as a power source for deep-based missile systems. Subjects of other recent contracts are (1) thermal stability of jet fuels, (2) general theory of electron detachment, (3) terrain analysis and siting, (4) radiography of helium pressure tank welds in MX missiles, and (5) microstructure of dielectric materials for optical coatings.

Proposed work includes materials characterization, study of radiation emitted in swift atom-solid bom-

bardment, studies of negative helium ions, and studies of high-temperature atom-molecule energy transfer processes.

**Defense Nuclear Agency.** Our long-standing program for the Defense Nuclear Agency—developing analytical methods and related nuclear data sets for calculating the transport of weapons radiations—is expected to continue. The major continuing emphasis is on modernizing the analysis methods to use contemporary computing equipment and making the analysis methods available to military components and contractors throughout the country. The program of specific design-support analyses for particularly difficult problems in radiation shielding is expected to expand with applications to programs in several parts of DOD in addition to the Defense Nuclear Agency.

### *Department of Transportation*

For the Department of Transportation, ORNL will continue to provide technical support for transportation energy-use studies related to vehicle testing and traffic flow analyses. ORNL is conducting road tests and dynamometer tests of several vehicles and developing software that simulates, on the basis of test data, the performance of these vehicles. In related work, ORNL is assisting in the evaluation and transfer of traffic flow models and related data bases.

### *Federal Emergency Management Agency*

Programs for the Federal Emergency Management Agency (FEMA) involve research in support of national civil preparedness in the event of nuclear attack or emergency. Our areas of support include civil, electrical, and mechanical engineering; electronics; and computer sciences and physics. Diverse topics are being studied, including, for example, the adaptability of earth-covered housing designs for blast and fallout protection, forecasting of radiation levels from fallout caused by multiple nuclear detonations, and the development of concepts and handbooks to strengthen the national radiological defense system. ORNL is continuing to provide engineering assistance relative to radiation detection. This includes the development of cheap, reliable, and rugged dosimeter chargers, technical assistance related to dosimeter manufacture, and consultation and assessment related to radiation detection instrumentation. Work for FEMA in these areas is expected to continue and expand moderately in the future.

## Nonfederal Organizations

The Laboratory also receives a small amount of funding from nonfederal organizations that rely on ORNL's unique facilities and expertise (e.g., EPRI). All programs sponsored by nonfederal organizations require DOE approval before being undertaken by the Laboratory.

# *New Initiatives*

The process of proposing new initiatives to DOE has allowed ORNL to identify and pursue important new areas of R&D in which we can make significant contributions. As a result, several of our past new initiatives have now grown into strong research endeavors at the Laboratory; the following table is a sample list of some of our successful new initiatives.

Other proposed new initiatives have not been funded to the same extent as those above, but the

| New initiative | FY proposed | Estimated FY 1982 FTEs[a] |
|---|---|---|
| Biotechnology Development | 1980 | 25 |
| Coal Chemistry | 1979 | 21 |
| Energy Risk Assessment | 1980 | 28 |
| Global Environmental Concerns | 1981 | 34 |
| Hazardous Waste Technology | 1981 | 25 |
| High-Temperature Materials | 1980 | 51 |
| Instrumentation for Fission Energy Systems | 1979 | 31 |
| National Environmental Research Park | 1979 | 2[b] |
| Toxicology | 1980 | 24 |

[a]In most cases, the number of full-time equivalent personnel (FTEs) involved in a new initiative when it was first proposed was very small or zero. However, some new initiatives had consolidated smaller on-going programs at ORNL into single, larger, united efforts (e.g., High-Temperature Materials) and, consequently, had some base support already involved in the research area.

[b]This new initiative is now an active user facility.

underlying research problems that these initiatives focus on still need to be addressed. Examples of these new initiatives are provided below.

| New initiative | FY proposed | Estimated FY 1982 FTEs[a] |
|---|---|---|
| Automation of Coal Cleaning | 1979 | 0.1 |
| Engineering Science Center | 1981 | 0.5 |
| Materials Development for Conservation and Solar Technologies | 1980 | 4.0 |
| Pressurized Fluidized Bed Combustor | 1979 | 3.4 |
| Strategic Materials for Energy | 1981 | 4.0 |

[a]Full-time equivalent personnel.

Although other past new initiatives have failed to materialize in any meaningful way because of a variety of circumstances, we find that the new initiative process is a useful means to highlight important areas of research that otherwise might not receive proper attention.

## New Initiatives for FY 1983–FY 1988

ORNL is proposing three new initiatives this year that deal with important research needs that ORNL is particularly qualified to address the Center for Surface Modification Research, Aging Effects in Nuclear Power Plants, and Remote Control Engineering for Remote Maintenance.

### *Center for Surface Modification Research (Director of Office of Energy Research)*

The production and examination of modified surfaces are important and growing components of research in the solid state physics program at ORNL. We propose that the pieces of research in this area be drawn together forming a center for research in surface modification. Existing facilities are already being expanded to help accommodate the strong interest in surface modification research from both in-house and outside users. The prognosis for continued growth is excellent because of the many technological advances that this research area promises. The principal techniques currently used in surface modifications are ion implantation doping and pulsed laser annealing; both are nonequilibrium processing techniques, and they have resulted in a variety of new and often unique materials properties. A research center is needed to give concerted attention to understanding the physical details of modified surfaces with the attendant development of new or improved techniques for producing modified surfaces tailored to have special surface properties (e.g., conduction, hardness, and corrosion resistance). Plans are being developed to initiate a formal users' program so that these unique facilities will be readily available to scientists both within and outside ORNL. User interest is already high and is now accommodated to the extent possible within the limited facilities available.

New funding for manpower would be small at the outset. Expanded facilities are the most critical need (see Table 17 of "Site and Facilities Development" for proposed FY 1986 line item, "Laboratory Research and Support Facility"). Support for surface modification research is provided by the BES Materials Sciences Division. Additional support required to establish a center would come from this division, which operates under the auspicies of the Director of the OER.

**Resource projections for Center for Surface Modification Research[a]**

| | '83 | '84 | '85 | '86 | '87 | '88 |
|---|---|---|---|---|---|---|
| Operating cost | 1.1 | 1.2 | 1.5 | 1.5 | 1.6 | 1.6 |
| Direct FTEs | 9 | 10 | 12 | 12 | 13 | 13 |
| Capital equipment | 0.6 | 1.7 | 0.3 | 0.3 | 0.3 | 0.3 |

[a]Data are for FY 1983 through FY 1988. Funding is in millions of 1982 dollars, and personnel numbers are in full-time equivalent (FTE) person years.

### *Aging Effects in Nuclear Power Plants (Nuclear Regulatory Commission and Assistant Secretary for Nuclear Energy)*

As nuclear power plant operating life advances, some degradation in its equipment and systems is

expected. Such degradation with age must be recognized and accommodated to ensure safe and reliable plant operation. Determination of appropriate corrective measures and design improvements would permit an extension of the design lifetimes of nuclear power plants and enhance their availability. The current concern with pressure vessel embrittlement has served to emphasize the need for NRC and DOE to initiate a comprehensive, systematic investigation of safety-related effects of aging for LWRs. Solutions to aging effects on plant availability and life expectancy that are not safety related should be undertaken by DOE.

A number of current NRC programs at ORNL are concerned with safety-related effects of aging. Experimental and analytical techniques have been developed for investigation of component performance in the following programs: Heavy Section Steel Technology; Evaluation of Pressurized Thermal Shock; Improved Eddy Current In-Service Inspection for Steam Generator Tubing; and Light-Water Reactor Pressure Vessel Irradiation. Large data bases have been developed containing operating, failure, and maintenance data for the following programs: Screening of Licensee Event Reports; Analysis of Reliability Data from Nuclear Power Plants; and Maintenance Error Model. Surveillance and diagnostic methods for incipient failure detection have been developed for the Continuous On-Line Reactor Surveillance System Program and the Noise Diagnostics for Safety Assessment Program.

New programs for joint sponsorship by DOE and NRC will be developed concerning phenomenology directed specifically at aging effects. Improved surveillance and diagnostic methods for incipient failure detection will be developed for rotating machinery, piping systems, pumps and valves, heat exchangers, and pressure vessels. Accelerated testing techniques will be developed for investigation of operating transients on electrical and mechanical equipment that has deteriorated because of exposure to high-temperature, high-pressure, high-neutron and gamma fluence, and highly contaminated, or highly corrosive environments. Probabilistic risk assessment and existing data bases will be used for the assessment of aging phenomena and the determination of resulting consequences and potential mitigative features. The scope and frequency of equipment testing that is necessary and the adequacy of maintenance procedures will also be addressed.

Funding for new programs concerned with aging phenomena will increase to a level representing about 20% of the total NRC Program effort by 1986. It is anticipated that both the NRC Office of Nuclear Regulatory Research (Engineering Technology, Risk Analysis, and Facility Operations divisions) and Office of Nuclear Reactor Regulation will sponsor these programs. Funding from the DOE Office of Converter Reactor Development will be sought.

**Resource projections for Aging Effects in Nuclear Power Plants**[a]

| | '83 | '84 | '85 | '86 | '87 | '88 |
|---|---|---|---|---|---|---|
| Operating cost | 0.5 | 1.0 | 3.0 | 6.0 | 6.0 | 6.0 |
| Direct FTEs | 3 | 5 | 15 | 30 | 30 | 30 |

[a]Resources do not include current Nuclear Regulatory Commission funding level of $5 million. Data are for FY 1983 through FY 1988. Funding is in millions of 1982 dollars, and personnel numbers are in full-time equivalent (FTE) person years.

## *Remote Control Engineering for Remote Maintenance (Assistant Secretary for Nuclear Energy and Director of Office of Energy Research)*

This proposed new initiative is based on an expansion of the existing remote maintenance development effort for breeder reactor fuel reprocessing conducted by the Fuel Recycle Division. The current development effort is focused on improving plant performance by providing increased capabilities to perform maintenance activities in reasonable times and reduce personnel exposures during such operations.

A majority of the remote engineering concepts in use today were developed many years ago. Argonne National Laboratory, in the period between 1949 and 1962, developed high-density windows and force-reflecting mechanical manipulators that led to a series of designs for small hot-cell facilities currently in use. In reprocessing, the U.S. production plants were designed for maintenance with only overhead cranes and impact wrenches. The more complex mechanical

equipment required for reprocessing power reactor fuel makes it desirable to adapt the human sense capabilities (sight, sound, and feel) utilized in small hot-cell systems to the large volume areas of a reprocessing plant.

Because ORNL's responsibilities include the conceptual design of reprocessing facilities, a system analysis has already been made of the development activities in remote control engineering required to fulfill the needs of a facility design. The system segments are: control design, mechanical design, television application, power transmission, signal transmission, transporter development, and the man/machine interface (ergonomics).

These development activities, begun in 1978, have been primarily focused on the needs of nuclear fuel reprocessing, but the generic base generated has a fundamental similarity to the needs in high-level nuclear waste, nuclear fuel fabrication, LWR maintenance, breeder reactor maintenance, fusion reactor maintenance, decontamination and decommissioning activities, and emergency recovery operations. ORNL developed the tooling and procedures and assisted in the dismantling of the Elk River Power Demonstration Reactor core. Although the nuclear field provides a fertile area, the same technology will be applied in time to underwater mining and drilling, counterterrorist activities, and military scenarios where the requirement exists to project human capabilities into hostile environments.

The current team effort is staffed by the Engineering Division, the Instrumentation and Controls Division, the Metals and Ceramics Division, the Fuel Recycle Division, and ORAU personnel. In addition, subcontracts for expertise outside the Laboratory have varied between 20 and 40% of the task expenditures. Current funding is $1.6 million for FY 1982, which includes about 14 FTE person-years.

The initial phase of this initiative would be devoted to establishing the needs for this effort outside the reprocessing field and converting these needs to required development and design work. The current activities have led to a dialogue with and expressions of interest from the fusion engineering groups (Oak Ridge and Princeton); to recovery operations—TMI (both facility recovery and core recovery); and to the Emergency Response Group. These groups have needs that require the technology but do not have the individual funds or the staff to undertake the required development and design.

Because the response to the requirements of all the groups inherently involves the same system mix, albeit in different proportions, there is an efficiency in this proposed centralized technology-development effort. The required products, which will be a mix of automation, robotics, and teleoperator systems, will be quite different but will all stem from similar basic technologies.

**Resource projections for Remote Control Engineering for Remote Maintenance[a]**

| | '83 | '84 | '85 | '86 | '87 | '88 |
|---|---|---|---|---|---|---|
| Operating cost | 2.3 | 3.5 | 5.0 | 5.5 | 6.0 | 6.6 |
| Direct FTEs | 20 | 30 | 43 | 43 | 50 | 50 |

[a]Data are for FY 1983 through FY 1988. Funding is in millions of 1982 dollars, and personnel numbers are in full-time equivalent (FTE) person years.

# TECHNOLOGY TRANSFER PROGRAM

# TECHNOLOGY TRANSFER PROGRAM

## *Overview*

The Oak Ridge National Laboratory (ORNL) Technology Transfer Program has been active since 1970, and the activities and objectives of this program satisfy the intent of the Stevenson-Wydler Technology Innovation Law. The current program, under the Office of Research and Technology Applications (ORTA), identifies new technologies having potential for transfer; publishes and distributes Technology Applications Bulletins for use by state and local governments and industry; and arranges workshops, briefings, and conferrals as necessary to encourage interaction. In addition, to encourage technology transfer, ORTA maintains regular contact with technology brokers including the Technology Information Center, the Federal Laboratory Consortium, and the National Technical Information Service (NTIS). Internally, ORTA monitors Laboratory programs through the twenty-three Divisional Technology Transfer Officers and the Program Planning and Analysis Office.

The organizational framework of ORNL's ORTA is displayed in Fig. 9.

## *Goal and Strategies*

The primary goal of ORTA is to support the Laboratory's mission in conformance with Sect. 11, paragraph (c), of the Stevenson-Wydler Technology Innovation Law. To implement this goal, we have defined several strategies:

- developing the staff-oriented infrastructure necessary to bring about early identification and adoption of new technologies;
- encouraging participation by private industry and state and local governments in ORNL research and development programs;
- promoting commercialization of ORNL technologies through an active program of establishing and maintaining contact with industry;
- promoting the development of consensus industrial standards to ensure that the information and experience gained in all programs is documented and made available to the public and private sectors through the efforts of the Nuclear Standards Management Center, information centers, and professional societies;
- identifying strategic needs of the public and private sectors that can be met by ORNL;
- establishing credibility for ORNL within industry and state and local governments by developing standardized procedures for access to information and assistance;
- assisting in the establishment of an effective national information exchange network within the Center for the Utilization of Federal Technology to increase federal productivity;
- limiting involvement to areas of strength within ORNL and referring other requests to federal facilities with appropriate capabilities; and
- evaluating program successes and failures and making appropriate modifications.

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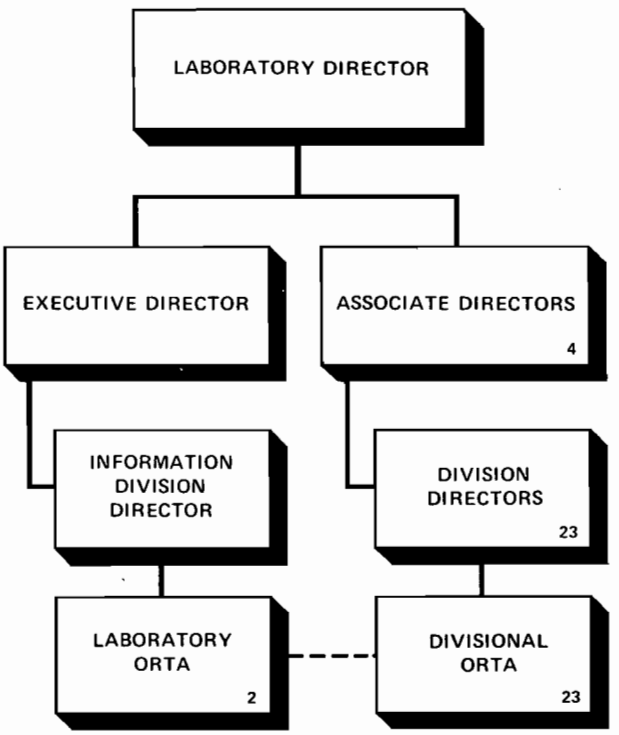


*Fig. 9. Organizational makeup and reporting level of ORNL's ORTA. (Figures in the lower right corners of each box represent the number of personnel involved.)*

# *Technology Transfer Process*

## Application Assessments

Each research division has its own ORTA that serves as the contact point for the Laboratory ORTA. Technologies having potential for transfer are normally identified by the Laboratory ORTA, and these are evaluated by a team comprised of the division and Laboratory ORTAs and the developers. Technology Applications Bulletins are published on all innovations or publications selected by the team. Innovations that have extensive technical documentation are forwarded to the Department of Energy's (DOE's) Technical Information Center (TIC) for inclusion in Energy Grams; all bulletins are sent to TIC, NTIS, trade press, technology brokers, industry, and state and local governments. Additional supporting information on a technology is furnished to potential users on request.

## Identification of Applications and Potential Users

Some of the most successful technology transfer activities at ORNL are informal and result from the staff's interaction with industry, universities, governmental agencies, and professional societies in day-to-day work activities. The many exchanges that take place in this process are frequently not documented but can represent as much as 20% of the working time of some researchers and program managers. This relationship with potential users enables ORNL staff members to judge the quality of their technologies and to identify the best market for them.

As Southeastern Regional Coordinator for the Federal Laboratory Consortium, the Laboratory ORTA Director is in frequent contact with technology broker organizations, other federal laboratories, and users. One-third of the requests for special assistance

received by the ORTA in FY 1982 were from technology brokers.

## Technology Transfer Services

In performing its technology transfer function, ORTA provides many services used by both the Laboratory staff and outside groups. Most of the services that are performed on a routine basis include:

- identification of national technology resources available through the Federal Laboratory Consortium,
- publication of Technology Applications Bulletins,
- consultation with state and local governments and industry concerning technical problems,
- conduct of new technology training classes,
- conduct of staff technology transfer training seminars,
- assistance in establishing nuclear and professional society code and standard certification,
- provision of emergency technical assistance to persons outside the Laboratory,
- assistance in establishing joint technology development contracts with industry,
- preparation of technology applications articles and news releases for trade press,
- support to industry and local government trade shows with technology transfer displays,
- provision of regional support for Tennessee Technology Corridor,
- conduct of workshops, and
- arrangement of personnel exchanges with industry.

Over the past year, ORNL's technology transfer efforts have included special technical support for a regional project called the Tennessee Technology Corridor. This project, which is sponsored by the Tennessee state government, is an effort to foster the location of high-technology firms in an area between Oak Ridge and Knoxville. Our technical assistance in this endeavor will be a continuing activity during the planning period.

# *Obstacles*

ORNL's experience with technology transfer activities has been very rewarding, and we believe that the overall program has been and continues to be quite effective. There are, however, two areas in which we find impediments to our technology transfer endeavors.

1. Because DOE support of technology transfer follows programmatic emphasis, funding frequently stops just as commercialization potential is greatest. Another unfortunate effect of the programmatic emphasis is that industry not closely related to the project may not recognize spinoffs of the program. Nonprogrammatic funding is needed to support industry-oriented technologies within all DOE programs. Funding of this type could be used to promote new technologies to a broader base of potential industrial users in addition to those closely associated with the program.
2. Federal printing limitations reduce the effectiveness of the ORNL Technology Transfer Program. Consideration should be given to providing printing limitation exemptions for technology transfer materials and scientific support material so that more information may be released to industry and state and local governments.

# *Resource Projections: Personnel and Funding*

Table 12 shows the resources allocated for operation of ORTA and an estimate of the resources devoted to technology transfer activities outside of ORTA for FY 1981 and FY 1982. Resources for the planning period FY 1983 through FY 1988 are expected to remain constant at the FY 1982 level. As a percentage of operating funds, ORNL's total technology transfer effort currently amounts to 3%.

Consequently, ORNL is in full compliance with the requirements of the Stevenson-Wydler Technology Innovation Act.

**Table 12. Estimated expenditures and staffing of ORNL's Technology Transfer Program**

| | FY | |
|---|---|---|
| | 1981 | 1982 |
| Funding, thousands of dollars[a] | | |
| ORTA[b] | 76 | 67 |
| Other | 10,220 | 10,220[c] |
| Total | 10,296 | 10,287 |
| Staffing, FTEs[d] | | |
| ORTA | 2 | 2 |
| Other | 60 | 60 |
| Total | 62 | 62 |

[a]FY 1982 dollars.

[b]ORNL's Office of Research and Technology Applications.

[c]Includes: workshops; conferences; assistance to state and local governments; standards certification; technology assessment; demonstration projects; publications for technology transfer; technology-training; and consulting services.

[d]Full-time equivalents.

# PERSONNEL RESOURCES

# PERSONNEL RESOURCES

The Oak Ridge National Laboratory's (ORNL's) technical staff, numbers 580 engineers, primarily chemical, electrical, and mechanical; 520 physical scientists; 240 biomedical and environmental scientists; 45 economists and other social scientists; and 15 mathematicians.* (See Fig. 10 for a frequency distribution on experience of the technical staff.) Forty-one percent of the Laboratory's total population is college graduates, of whom more than 850 hold the Ph.D. degree.

In addition to ORNL technical staff and guests, the Union Carbide Corporation–Nuclear Division central organization has a general engineering staff of 1250 and a computer sciences staff of 830. Currently, ORNL uses about 323 of the available engineering staff and 326 of the computer sciences staff. ORNL programs located at the Y-12 Plant use over 600 of the service and support staff located there. Also, about 140 individuals from central management service groups provide ORNL support (Fig. 11).

*Includes part-time personnel.

## *Personnel Trends and Requirements*

Following the peak employment of FY 1968, personnel levels declined until FY 1974. Growth was experienced from FY 1974 to FY 1978 and level staffing from FY 1978 through FY 1981. The staff was reduced by about 300 people during the last part of FY 1981 because of FY 1982 budget cuts and by another 400 people during the last part of 1982 as a result of projected budget cuts for 1983. The major impact of these recent reductions has been felt in the life sciences, fossil energy, energy conservation, and support groups. Because of normal attrition, transfers, and voluntary reductions-in-force, only a minimal

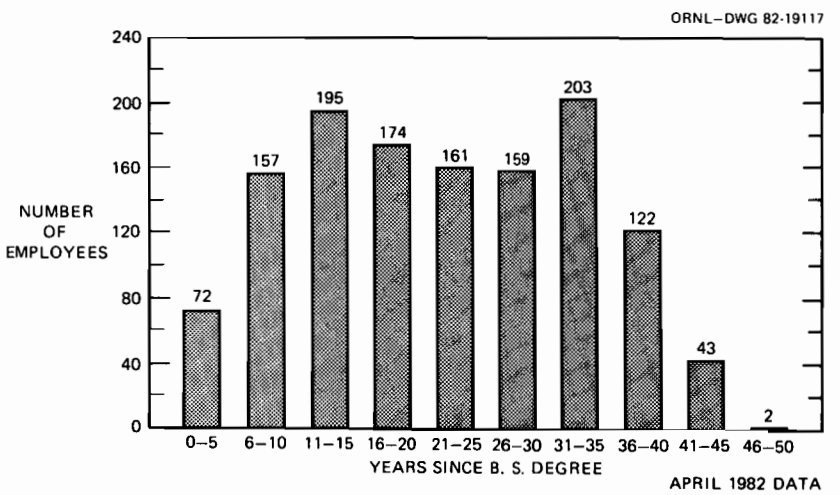


*Fig. 10. Frequency distribution showing experience of the full-time technical staff.*

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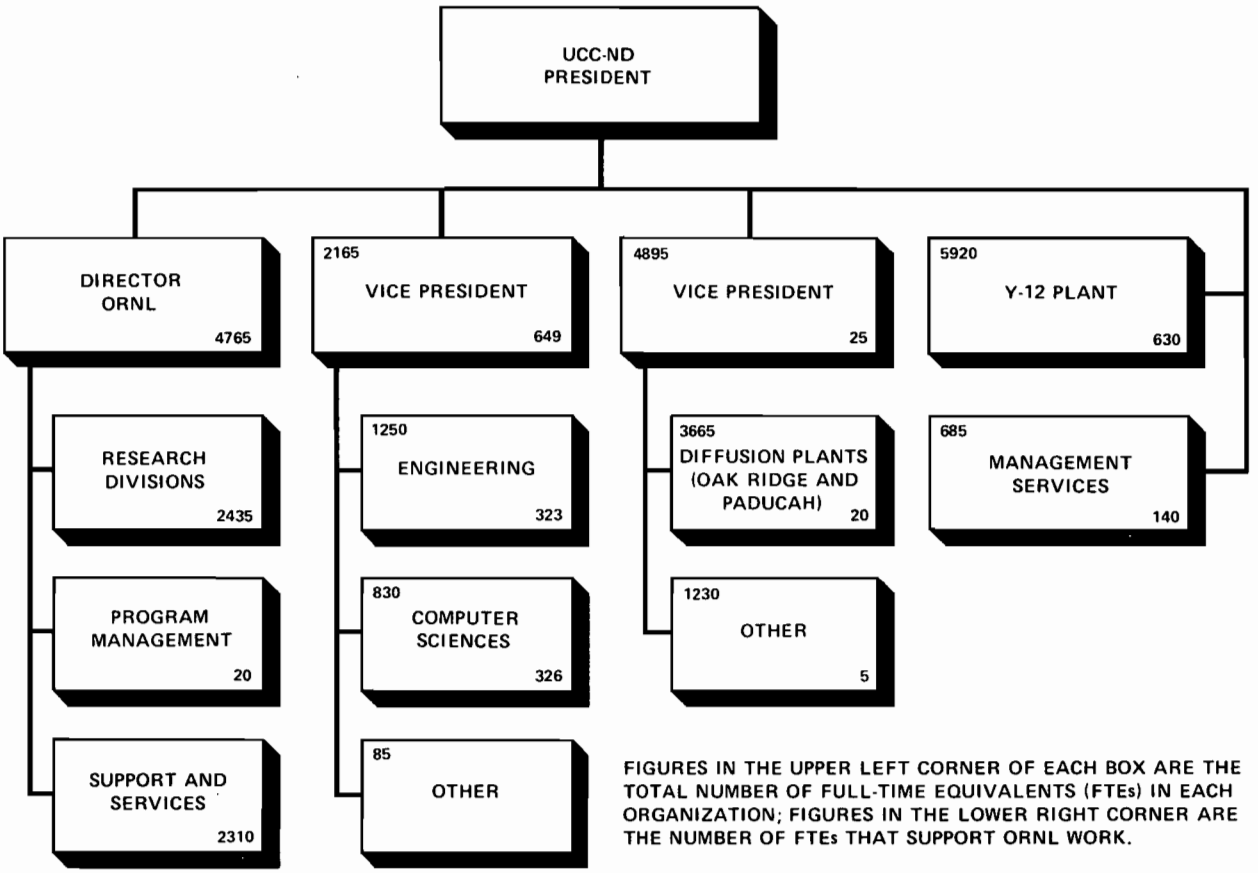


*Fig. 11. ORNL receives extensive support from other parts of UCC-ND, as is indicated by these March 1982 employment figures.*

number of persons were actually given layoff notices. Outplacement programs were developed to assist those employees receiving layoff notices.

Personnel requirements for the next two years will be such that recruiting will be minimal, mostly to replace attrition in critical programs. ORNL currently has an overall recruiting acceptance rate of 78% (69% for Ph.D.s and 91% for B.S./M.S. candidates).

## *Affirmative Action Program*

Emphasis on upward mobility and employee development will continue to be the focus of the Laboratory's Affirmative Action Program throughout the eighties. Even during the severe declines in staffing, the representation of minorities and women remains relatively stable in the organization at around 9 and 25%, respectively. Also, an increasing number of minorities and women are being promoted into management positions. As opportunities become available, the Laboratory will continue to recruit qualified minority and women candidates for technical and professional positions, especially in the engineering disciplines. Qualified individuals with handicapping conditions, especially those with technical backgrounds, will continue to receive support in gaining meaningful employment. Besides these areas, the Laboratory will continue to enhance its Affirmative Action Program through management and supervisory training and ongoing publicity efforts.

## *Personnel Development Programs*

Emphasis will continue to be placed on in-house development of the existing Laboratory population to assure the proper availability, optimum utilization, and

continuing welfare of employees who are best able to contribute to the achievement of Laboratory objectives. Such development programs include

- In-Hours Continuing Education Program for Scientific and Technical Personnel,
- Management Resource Development, and
- In-House Development Program for Administrative and Technical Support Personnel.

A Career Planning Program is now available throughout the Nuclear Division to help salaried employees plan their own career strategies. Interaction modeling training methods continue to be stressed in the development of first-line supervisors. Several of these programs have been modified to provide learning opportunities for the hearing impaired.

# UNIVERSITY AND INDUSTRY INTERACTIONS

# UNIVERSITY AND INDUSTRY INTERACTIONS

The Laboratory recognizes the value of its interactions with universities and industry in advancing Department of Energy (DOE) research programs. A long history of extensive interactions has been established and, in recent years, these interactions have expanded and have become more diverse.

The Oak Ridge National Laboratory (ORNL) interacts with universities and industry through subcontracts, user facilities, guest assignees, technology transfer activities, and special programs, all of which are described in more detail below and elsewhere in this planning document. Also described below are the special efforts made to involve minority and disadvantaged institutions in the Laboratory's program.

A special area of university interaction is the operation of the University of Tennessee's Oak Ridge Graduate School of Biomedical Sciences, which is located within the ORNL Biology Division. The program is primarily designed for training leading to the Ph.D. degree, although there are a few master's degree candidates. The students are supported by the University of Tennessee in the form of research assistantships or federal training grants awarded to the School by the National Cancer Institute and the National Institutes of Health. Currently, there are 46 students working toward the Ph.D. degree and four in the Master's program. The School has been operating for 16 years, during which time 76 students have been awarded the Ph.D. degree, and 11 students have received the M.S. degree. The students form a very active group of investigators, and they contribute significantly to the productivity and excellence of the Biology Division.

## *Subcontracting and Procurement*

One of the two major expenditures incurred from interactions with institutions outside the Laboratory is subcontracting, the other is procurement. Figure 12 shows that these expenditures grew substantially between FY 1976 and FY 1980, but that some recent declines are occurring because of decreased field management activities and cuts in overall DOE programs. Table 13 gives the value of subcontracts and procurements conducted with small and small disadvantaged businesses during recent years.

## *Laboratory User Facility Participation*

ORNL operates several large experimental facilities that are used extensively by both universities and industry. More than 100 universities and over 20 industrial firms have used these unique research facilities. Use of the facilities by outside institutions is increasing, and major increases among industrial users are expected as the capabilities of some of the newer facilities become more publicized. Table 14 describes the extent to which each facility is used by ORNL and other institutions.

## *University-Laboratory Programs*

Interactions between the Laboratory and the university community continue to provide a two-way

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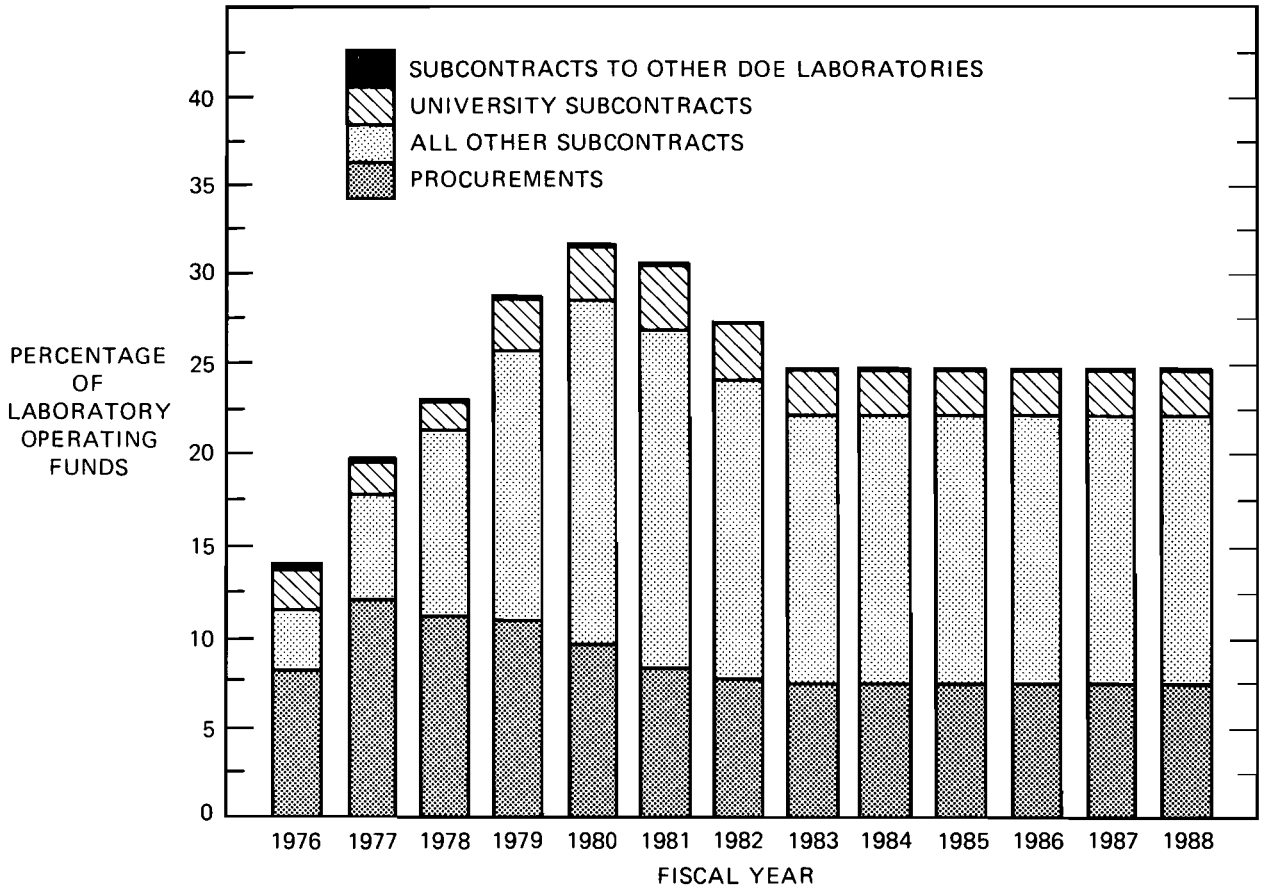


*Fig. 12. Percentages of Laboratory operating funds used for subcontracting and materials procurement.*

**Table 13. Subcontracting and materials procurement conducted with small and small disadvantaged business firms**

| | Subcontracts and procurements (millions of dollars) | | | | |
|---|---|---|---|---|---|
| | FY 1978 | FY 1979 | FY 1980 | FY 1981 | FY 1982 |
| Small business firms | 21.7 | 28.8 | 34.2 | 33.8 | 34.5 |
| Small disadvantaged business firms | NA[a] | NA | 2.7 | 3.9 | 3.7 |

[a]NA—data not available.

**Table 14. ORNL user facility participation**

| | Fiscal year | | | | |
|---|---|---|---|---|---|
| | 1978 | 1979 | 1980 | 1981 | 1982 |
| **EN-Tandem Van de Graaf Accelerator** | | | | | |
| Experimenter personnel | | | | | |
| University | 20 | 20 | 20 | 20 | 20 |
| ORNL | 1.5 | 1.5 | 1.5 | 1.5 | 1.6 |
| Use ratio, % | | | | | |
| University | 25 | 25 | 25 | 25 | 25 |
| ORNL | 75 | 75 | 75 | 75 | 75 |
| Total operating cost, millions of dollars | 0.14 | 0.15 | 0.16 | 0.18 | 0.20 |
| **Oak Ridge Electron Linear Accelerator** | | | | | |
| Experimenter personnel | | | | | |
| University | 8 | 8 | 8 | 8 | 10 |
| Industry | 5 | 5 | 5 | 5 | 5 |
| ORNL | 14 | 14 | 14 | 14 | 14 |
| Other national laboratories | 3 | 3 | 3 | 3 | 3 |
| Others | 2 | 2 | 2 | 2 | 2 |
| Use ratio, % | | | | | |
| University | 9 | 9 | 9 | 9 | 9 |
| Industry | 5 | 5 | 5 | 5 | 5 |
| ORNL | 85 | 85 | 85 | 85 | 85 |
| Other national laboratories | 1 | 1 | 1 | 1 | 1 |
| Total operating cost, millions of dollars | 1.0 | 1.1 | 1.2 | 1.3 | 1.4 |
| **University Isotope Separator** | | | | | |
| Experimenter personnel | | | | | |
| University | 19 | 24 | 26 | 25 | 21 |
| ORNL | 1 | 2 | 2 | 3 | 3 |
| Other national laboratories | 2 | 2 | 3 | 3 | 2 |
| Others | 4 | 4 | 3 | 3 | 3 |
| Use ratio, % | | | | | |
| University | 78 | 64 | 90 | 69 | 62 |
| ORNL | 5 | 20 | 4 | 18 | 18 |
| Other national laboratories | 14 | 9 | 2 | 8 | 3 |
| Others | 3 | 7 | 4 | 5 | 17 |
| Total operating cost, millions of dollars | 0.20 | 0.21 | 0.27 | 0.36 | 0.40 |
| **Shared Research Equipment** | | | | | |
| Experimenter personnel | | | | | |
| University | | 25 | 35 | 40 | 45 |
| Industry | | | 3 | 6 | 6 |
| ORNL | | 3 | 3 | 3 | 3 |
| Other national laboratories | | | | 1 | 1 |
| Others | | | | 1 | 1 |
| Use ratio, % | | | | | |
| University | | 15 | 20 | 25 | 25 |
| Industry | | | 3 | 5 | 5 |
| ORNL | | 85 | 77 | 75 | 75 |
| Other national laboratories | | | | | |
| Others | | | | | |
| Total operating cost, millions of dollars | | 0.40 | 0.45 | 0.50 | 0.50 |

**Table 14 (continued)**

| | Fiscal year | | | | |
|---|---|---|---|---|---|
| | 1978 | 1979 | 1980 | 1981 | 1982 |
| **Oak Ridge National Environmental Research Park** | | | | | |
| Experimenter personnel | | | | | |
| University | | | 1 | | 2 |
| ORNL | | | 10 | 12 | 15 |
| Others | | | 4 | 13 | 11 |
| Use ratio, % | | | | | |
| University | | | 0.5 | | 2 |
| ORNL | | | 90.5 | 89 | 96 |
| Others | | | 9 | 11 | 2 |
| Total operating cost, millions of dollars | | | 0.141 | 0.123 | 0.123 |
| **National Center for Small-Angle Scattering Research** | | | | | |
| Experimenter personnel | | | | | |
| University | | | | 80 | 100 |
| Industry | | | | 15 | 20 |
| ORNL | | | | 0.7 | 3.2 |
| Other national laboratories | | | | 6 | 6 |
| Others | | | | 4 | 4 |
| Use ratio, % | | | | | |
| University | | | | 85 | 85 |
| Industry | | | | 10 | 10 |
| ORNL | | | | 5 | 5 |
| Other national laboratories | | | | <5 | <5 |
| Total operating cost, millions of dollars | | | | 0.15 | 0.58 |
| **Holifield Heavy Ion Research Facility** | | | | | |
| Experimenter personnel | | | | | |
| University | | | | 60 | 65 |
| Industry | | | | 1 | |
| ORNL | | | | 22 | 22 |
| Other national laboratories | | | | 10 | 12 |
| Others | | | | 20 | 20 |
| Use ratio, % | | | | | |
| University | | | | 36 | 36 |
| Industry | | | | <1 | |
| ORNL | | | | 60 | 60 |
| Other national laboratories | | | | 4 | 4 |
| Others | | | | <1 | <1 |
| Total operating cost, millions of dollars | | | | 2.5 | 2.8 |
| **Surface Modification Laboratory** | | | | | |
| Experimenter personnel | | | | | |
| University | | | | 10 | 12 |
| Industry | | | | 8 | 10 |
| ORNL | | | | 7 | 9 |
| Others | | | | 3 | 3 |
| Use ratio, % | | | | | |
| University | | | | 15 | 15 |
| Industry | | | | 20 | 20 |
| ORNL | | | | 65 | 65 |
| Others | | | | ~1 | ~1 |

**Table 14 (continued)**

| | Fiscal year | | | | |
|---|---|---|---|---|---|
| | 1978 | 1979 | 1980 | 1981 | 1982 |
| **Surface Modification Laboratory** | | | | | |
| Total operating cost, millions of dollars | | | | 0.8 | 0.9 |

flow of technical information through formal programs and informal associations. Table 15 summarizes participation in energy R&D under the direction of the Laboratory's technical staff. The participation at ORNL during FY 1981 is summarized by type of program and by academic level of people temporarily assigned to programs.

The sources of funding for these programs are the DOE University-Laboratory Cooperative Program; ORNL's operating funds; and guest sponsorship funds from educational institutions, agencies, or fellowships.

A total of 1052 people from the academic community participating in research programs at the Laboratory is representative of our experience for the past several years (1000 or more annually). Many of the 248 undergraduates received academic credit from their respective universities as a result of their assignment at the Laboratory, and most of the 362 graduate students were engaged in master's or doctoral research. Of the 364 faculty included in the table, more than 30 are Laboratory employees on a part-time, year-round basis as adjunct research participants. Of the 78 postdoctoral fellows, five were recipients of the Laboratory's prestigious Eugene P. Wigner fellowship. At least 238 different universities sponsored the representatives from academia.

The ORAU Traveling Lecture Program is also funded by DOE, and last year the program listed 91 staff members from ORNL; lectures were presented at 67 universities.

The continuing increase in the number of guests from the university community is caused in part by the increased availability of ORNL facilities designated for user groups.

## *Minority University Programs*

For a number of years minorities from the historically black colleges 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.

A special summer program for undergraduates in science and engineering, for which students from minority institutions have been especially encouraged to apply, was established several years ago. Nine students were supported in 1981.

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

The Laboratory has a continuing effort to establish cooperative programs with minority universities. For example, representatives from three of these institutions (North Carolina A & T, Tennessee State, and Atlanta University) accepted invitations to visit the Laboratory two years ago to discuss possibilities of increased interaction. As a result, a subcontract arrangement with North Carolina A & T was satisfactorily completed. Negotiations are also in progress with North Carolina Central in an effort to develop a co-op program for students interested in health physics.

In FY 1981, the Laboratory endorsed and agreed to support a proposal for a summer institute in computer science to be sponsored by Knoxville College and the National Science Foundation (NSF); the proposal is still pending.

**Table 15. Summary of ORNL University-Laboratory programs for FY 1981**

| Program | Under-grads | Grads | Faculty | Post-doctoral | Total people | Total no. of universities |
|---|---|---|---|---|---|---|
| DOE University-Laboratory Cooperative Programs | | | | | | |
| ORNL funded | | | | | | |
| Environmental Sciences Cooperative Curriculum | 4 | | | | 4 | 4 |
| Great Lakes Colleges Association/Associated Colleges of the Midwest—Oak Ridge Science Semester | 35 | | 4 | | 39 | 25 |
| Southern College University Union—Oak Ridge Science Semester | 20 | | 1 | | 21 | 8 |
| MIT Oak Ridge School of Chemical Engineering Practice[a] | | 28 | 2 | | 30 | 1 |
| Reactor Training Cooperative Experiments | | 35 | | | 35 | 3 |
| ORAU funded | | | | | | |
| Faculty Research Participants | | | 10 | | 10 | 9 |
| Student Research Participants | 56 | | | | 56 | 51 |
| Laboratory Graduate Participation | | 11 | | | 11 | 6 |
| Postgraduate Research Training | | | | 3 | 3 | 2 |
| ORNL programs (operating funds) | | | | | | |
| Faculty Research Participants | | | 9 | | 9 | 9 |
| Summer Research Internships | | 27 | | | 27 | 27 |
| Special Summer AA[b] Program | 9 | | | | 9 | 7 |
| Forestry Program | 2 | | | | 2 | 2 |
| Pre-co-ops (AA) | 4 | | | | 4 | 4 |
| Co-ops | 89 | | | | 89 | 21 |
| Oak Ridge Graduate School of Biomedical Sciences | | 55 | 7 | 35 | 97 | 1 |
| Wigner Fellows | | | | 5 | 5 | 4 |
| ORNL guests (other sponsorship) | 29 | 206 | 235 | 35 | 505 | c |
| ORNL consultants | | | 96 | | 96 | 54 |
| Totals | 248 | 362 | 364 | 78 | 1052 | 238 |

[a]Discontinued in FY 1982.
[b]Affirmative Action.
[c]Information not available.

Efforts to enhance ORNL's relationship with black colleges and universities in the Southeast will continue to be explored within the constraints of our declining budget.

## *Small and Small Disadvantaged Business Programs*

The UCC-ND Purchasing Division has the responsibility for implementing an effective program to involve small and small disadvantaged business firms as suppliers of materials and services for ORNL as well as the other three installations operated by UCC-ND. Management's policy regarding purchases from these firms is to provide them with the maximum practicable opportunity to furnish the materials and services required. ORNL management is fully committed to support of this objective and is regularly apprised of progress in meeting goals for procurement with these firms.

The primary elements of the small and small disadvantaged business programs are provided below.

- Each year, challenging procurement goals are established to obtain increasing involvement from small and small disadvantaged business firms.
- A management committee from ORNL and UCC-ND's other operations serves to identify research and development and engineering support require-

ments appropriate for small and small disadvantaged business firms.

- A Small Business Coordination Department exists within the Purchasing Division to focus solely on the program.
- All construction subcontracts are reserved for small or small disadvantaged firms.
- All fuel coal subcontracts are reserved for small or small disadvantaged firms.
- All other procurements under $10,000 are reserved for small or small disadvantaged firms unless the requirement for big business is fully justified.

Other outreach activities include the participation in workshops with local area disadvantaged business organizations and attendance at trade shows sponsored by small and small disadvantaged businesses to seek out new sources for the program.

# SITE AND FACILITIES DEVELOPMENT

# SITE AND FACILITIES DEVELOPMENT

The Oak Ridge National Laboratory's (ORNL's) facilities are located primarily in two valleys within the Department of Energy's (DOE's) Oak Ridge Reservation. Of the Laboratory's approximate 370,000 $m^2$ (4 million $ft^2$) of building space (Fig. 13), 140,000 $m^2$ (1.5 million $ft^2$) is located in Bear Creek Valley at the Oak Ridge Y-12 Plant. And 230,000 $m^2$ (2.5 million $ft^2$) is located in Bethel Valley at the main ORNL site (Fig. 13). A small portion of the facilities at the main ORNL site are located south of Bethel Valley in Melton Valley and other remote locations.

ORNL inherited most of its facilities at Y-12 as surplus space from the Manhattan Project. These facilities were built in the early 1940s to serve activities associated with uranium enrichment. Currently, these facilities serve research in the Fusion, Biology, and Engineering Technology divisions and the Opera-

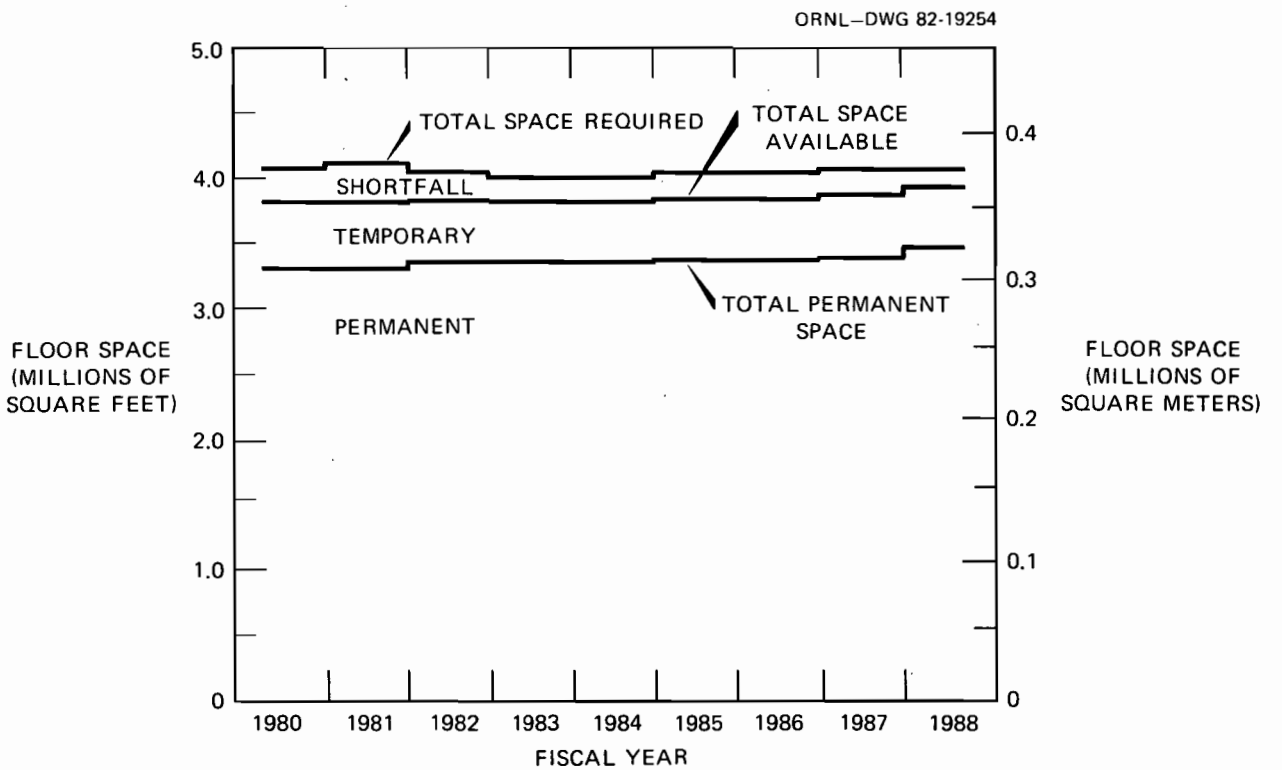


*Fig. 13. ORNL total space.*

tions Division's isotope production functions. The space is typically used for heavy and light laboratories* with associated office, shop, and support spaces.

The main ORNL site also began in the early 1940s with the construction of a large number of "temporary" wood frame and quonset type structures as well as several buildings of more permanent construction. The major portion of the permanent buildings currently at ORNL were built during the early 1950s and the early 1960s. Over 80% of the Laboratory's current buildings were completed before 1965. These facilities serve a wide variety of research and administrative activities. The research space is typically used for light laboratories, but it also includes various reactors, accelerators, and other large machine spaces. These are supplemented by office, computer, shop, and other support spaces.

*Heavy laboratories are characterized by high ceilings, typically equipped with overhead cranes, and capacities for handling heavier-than-normal floor loadings. All others are light laboratories.

## *Status of Facilities*

Because of the age of the facilities (Fig. 14) and a lack of funding support for renewing facilities, the Laboratory is now confronted with a significant backlog of projects required to overcome obsolesence and age deterioration (Table 16). Age-deteriorated utility systems require excessive maintenance expense, limit programmatic operating flexibility, and on occasion have shut down research activities when failure occurs. Utility system upgrades are a primary focus of ORNL's facilities planning strategy.

The maintenance program, constrained by reduced operating dollars, cannot by itself rectify the Laboratory's facilities situation. For this reason, the Laboratory proposed to solve its facilities aging and obsolesence problems through an aggressive, but real-

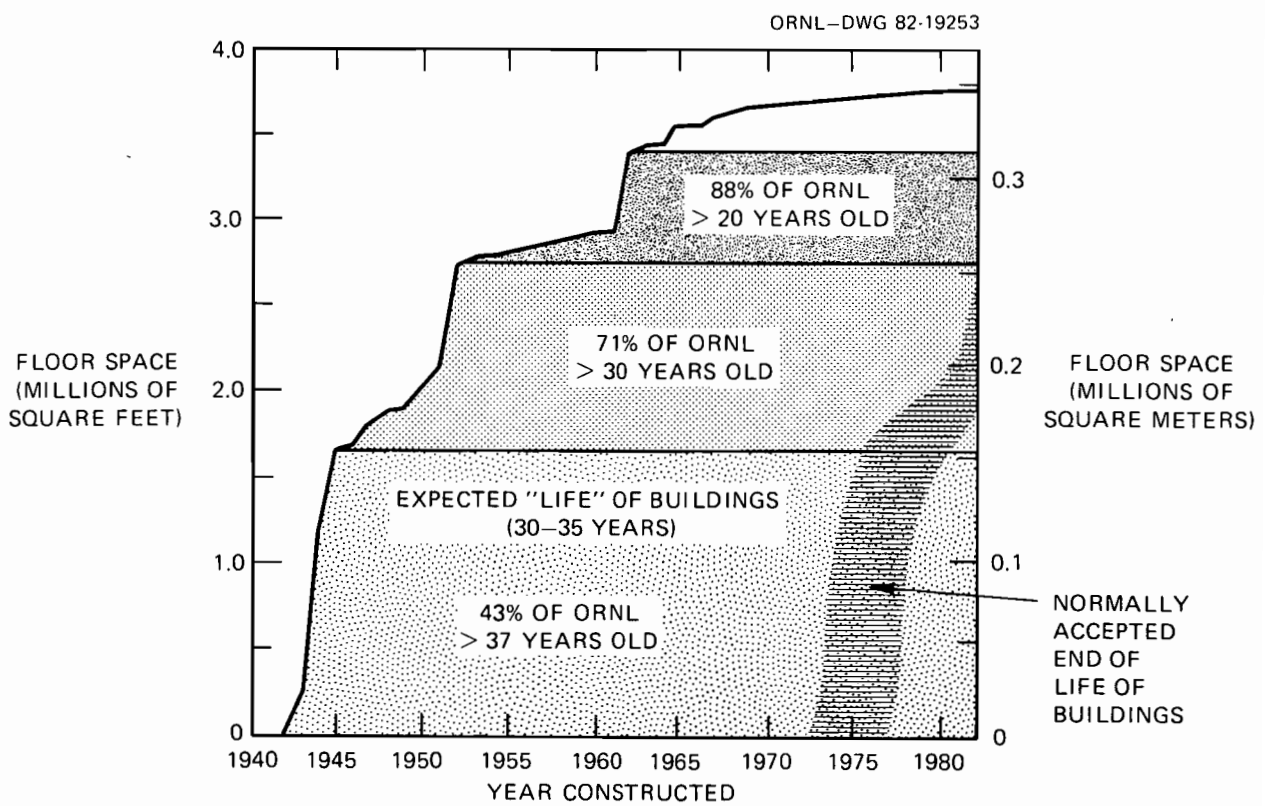


*Fig. 14. Age of buildings at ORNL.*

**Table 16. ORNL facilities condition summary, FY 1984–FY 1988**

| | Floor space (1000 m²) | Replacement value[a] | Requiring rehabilitation | | Requiring replacement | | Additional space required | |
|---|---|---|---|---|---|---|---|---|
| | | | % | Cost[a] | % | Cost[a] | % | Cost[a] |
| Buildings | | | | | | | | |
| Administrative office | 22 | 66 | 1 | 0.4 | 33 | 9.5 | | |
| Light laboratory | 268 | 1052 | 45 | 37.1 | 10 | 31.1 | 6 | 23.1 |
| Heavy laboratory | 3 | 20 | | | | | | |
| Storage | 22 | 25 | | | 19 | 4.7 | 16 | 3.7 |
| Service | 31 | 44 | 5 | 1.0 | 3 | 13.4 | 4 | 15.6 |
| Other | 8 | 117 | | | 39 | 4.6 | | |
| Subtotal | | | | 38.5 | | 63.3 | | 42.4 |
| Utilities | | | | | | | | |
| Mechanical | | 76 | 17 | 12.0 | 20 | 13.8 | | |
| Electrical | | 72 | 5 | 3.6 | 50 | 33.1 | | |
| Other | | 91 | 7 | 6.0 | 13 | 10.8 | 5 | 3.7 |
| Subtotal | | | | 21.6 | | 57.7 | | 3.7 |
| Site improvements | | | | | | | | |
| Road and other structures (subtotal) | | 31 | 1 | 0.1 | 1 | 0.2 | 32 | 9.3 |
| Total | | | | 60.2 | | 121.2 | | 55.4 |

[a]Millions of FY 1984 dollars.

istic, long-term program of facilities renewal coupled with appropriate maintenance activities.

## *Impact of Contractor Change*

An additional factor that could have significant impact on the Laboratory's facilities is the planned contractor change. Currently, ORNL, as an integral part of the Union Carbide Corporation–Nuclear Division (UCC-ND), obtains a significant amount of services from Nuclear Division personnel who are not housed in ORNL facilities but in facilities at other locations. Because of the uncertainty of how the DOE Oak Ridge installations will be operated in the future, provisions for added ORNL facilities to accommodate the required service personnel await DOE resolution of the future contractual arrangement.

## *Facilities Planning and Management*

The review of ORNL's draft site development plan by DOE has been completed. The Laboratory is currently revising the plan to tie it more closely to the *Institutional Plan*. In addition to the site development plan, the Laboratory uses additional facilities planning and management activities.

## Facilities Maintenance

Maintenance management in the ORNL Plant and Equipment Division uses a computerized Work Management System (PEWMS). Through this system, administrative-support personnel and costs are kept to a minimum; job planning, control, and evaluation have been strengthened; and the priorities of the work backlog are established.

PEWMS contains adequate historical data, includes an effective inspection program, and provides information for responsible decision making. It helps to concentrate maintenance efforts on the most critical needs and facilitates the wise use of available funds. Customer appraisals, coupled with significant increases in productive work output per employee, indicate the success of our progressive and effective productivity improvement program.

In addition to the PEWMS, the facilities evaluation studies described below are expected to provide information that will enable the Laboratory to make more knowledgeable maintenance decisions and thereby reduce cost requirements and potential failures. Further, these studies are expected to identify obsolete temporary facilities that can be retired and thereby reduce the overall maintenance liability.

## General Plant Projects

Significant progress has been made in the past year toward the more effective expenditure of our limited general plant projects (GPP) funds. Early identification of candidate projects has permitted the Laboratory management review to be completed and projects forwarded to DOE for approval in May before the budget year. By September, 90% of the projects had received tentative approval by DOE, which permitted the beginning of design immediately following the receipt of directives and funds. The timely start is expected to permit all projects to be finished within two years after the budget year.

To ensure the appropriate use of GPP funds in the restoration of the Laboratory, the proposed corrective measures (PCMs) identified in the 1981 Multiprogram General Purpose Facilities (MGPF) survey have been updated and integrated into the annual budget calls for projects.

Facilities evaluation studies have begun to more clearly identify the corrective measures necessary to restore the Laboratory facilities. They will focus initially on site support systems (i.e., power, water, steam, sewer, etc.). Additional studies of buildings, buildings support systems, and other site improvements will also be accomplished. These studies will determine the

- extent to which the facility fulfills current and projected functions,
- deficiencies and future needs,
- corrective measures and future development,
- cost and priorities of remedial actions and development, and
- facility upgrade and development actions for the next twenty years.

## Multiprogram General Purpose Facilities

As with the GPP program, the MGPF program has been guided by the PCMs identified in the 1981 MGPF survey. Subsequently, two revisions to that basic listing of deficiencies have occured. The first revision eliminated those measures that had been accomplished or were no longer required because of programmatic redirections. The second revision identified those measures for which corrective action should be given highest priority during the planning period. The facilities evaluation studies described above are expected to more clearly define our most crucial MGPF needs.

## Programmatic Line Items

Facilities needs are addressed as new research endeavors are planned; when existing facilities are determined to be inadequate, new facilities or upgrading of existing facilities are proposed. In addition, general facilities upgrade of individual programmatic facilities are proposed when existing facilities are determined to adversely affect ongoing programs because of obsolete, inadequate, deteriorated, or inefficient conditions.

## Nuclear Waste Programs—GPP and Line Items

These funding resources are, as the name implies, reserved for use on facilities related to the Laboratory's nuclear wastes. They are not used for overall Laboratory general purpose facilities. The Laboratory is preparing a long-range radioactive waste management plan that will provide a comprehensive listing and priority ranking of all needed nuclear waste facilities.

## In-House Energy Management Retrofit and Line-Item Projects

A series of very-cost-effective energy management projects has begun at ORNL. These projects, along with other conservation measures, are expected to

allow the Laboratory to minimize the impact of escalating fuel cost. The focus for the future includes the continuation of these efforts, the installation of an energy monitoring and control system (EMCS) at ORNL (FY 1984 line item), and the improvement of energy measures in the ORNL facilities at Y-12, in particular, the Biology Division facilities.

The EMCS is projected to save approximately $924,000 per year. Retrofitting the Biology facilities will save approximately $300,000 per year and significantly reduce their utility cost, which has run at 31% of that division's operating dollars.

## *Facilities and Equipment Funding Goals*

In the following section the Laboratory presents its facilities and equipment funding goals for the planning period FY 1983 through FY 1988. These goals represent the level of funding support in each category necessary to maintain ORNL as a viable long-term national resource. They are based on actual needs and not on extrapolations of past funding levels nor on indications of future funding availability.

### Facilities Maintenance

The funding level required to appropriately maintain the Laboratory is inextricably related to the other facilities' funding resources. Given the age, condition, and obsolescence of a significant part of our facilities and equipment, it is apparent that a course of action resulting in the rehabilation or replacement of these items is the most prudent and cost effective long-term approach. However, as can be seen in the GPP, MGPF, and general purpose equipment (GPE) sections, the amount of dollars required for renewal is very large. For this reason, it is likely that some of the burden of these aged facilities will be placed on maintenance to keep them operational until renewal can occur.

Figure 15 projects total maintenance expense (including plant protection) compared with total plant replacement value. The plant replacement value is expected to remain constant over the planning period at a value in excess of $1 billion. Two maintenance expense curves are shown. The lower curve represents projected expenses based on a constant overhead rate. The upper curve projects the expenses required to maintain the existing facilities, assuming that only limited renewal occurs. In the case of the upper curve, an additional $20 million of Laboratory operating funds would be required for maintenance during the planning period. This would represent a significant decrease in research funds available to many minimally funded research programs. To prevent maintenance expenses from expanding to the high funding burden indicated by the upper curve, increases in GPP and MGPF support are crucial.

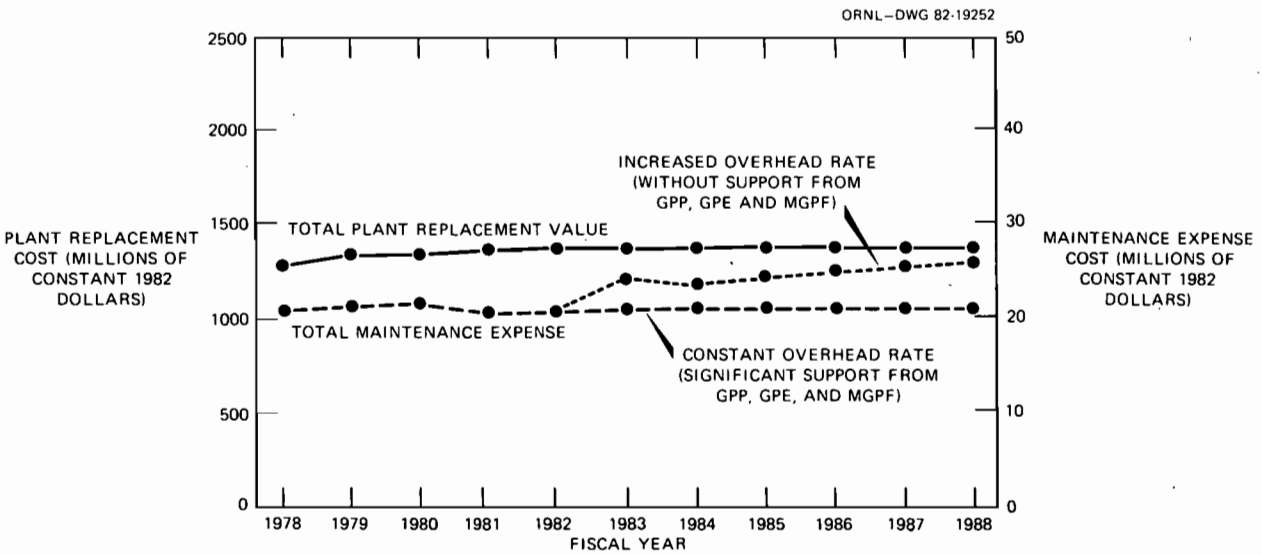


*Fig. 15. Plant value versus maintenance expense.*

## GPP Funding Goals

The past lack of GPP funding, coupled with a lack of line-item funding, has resulted in the development of a significant backlog of facilities deficiencies. The updated MGPF inventory of deficiencies indicates that the Laboratory faces a backlog of deficiencies of approximately $230 million. Not all of these deficiencies are, however, most logically corrected with GPP funds. It is estimated that at least 50% of them will require line-item support, which means the GPP backlog of general purpose facilities deficiencies would be about $100 million. A more refined estimate of this backlog will result from the facilities evaluations studies now underway.

As a further means of determining the Laboratory's GPP needs, a comparison was made between the current GPP needs and those during historical periods when GPP funding was perceived to be in balance with the overall operation of the Laboratory (1960s). The following factors were considered: overall onsite funding level, rate of real change in funding, rate of change in program direction, the overall size of the facilities currently in use, and their average age and condition. For example, the rate of real change in funding level impacts the GPP needs approximately as follows:

| | |
|---|---|
| Steady state | 0.025 × overall onsite funding, |
| Moderate growth | 0.030 × overall onsite funding, and |
| Rapid growth | 0.035 × overall onsite funding. |

This approach is shown in Fig. 16, which indicates a needed GPP funding level for FY 1983 of about $13 million. It also indicates a significant shortfall of GPP funds since the early 1970s that has generated the $100 million backlog.

The Laboratory's GPP goal to begin to reduce this backlog and maintain adequate GPP funding to support on-going activities for the planning period is shown in Fig. 17. The figure indicates a significant upturn of GPP funding in FY 1984 through FY 1986 with a leveling off in FY 1987 and FY 1988. Obtaining these projected goals would permit the

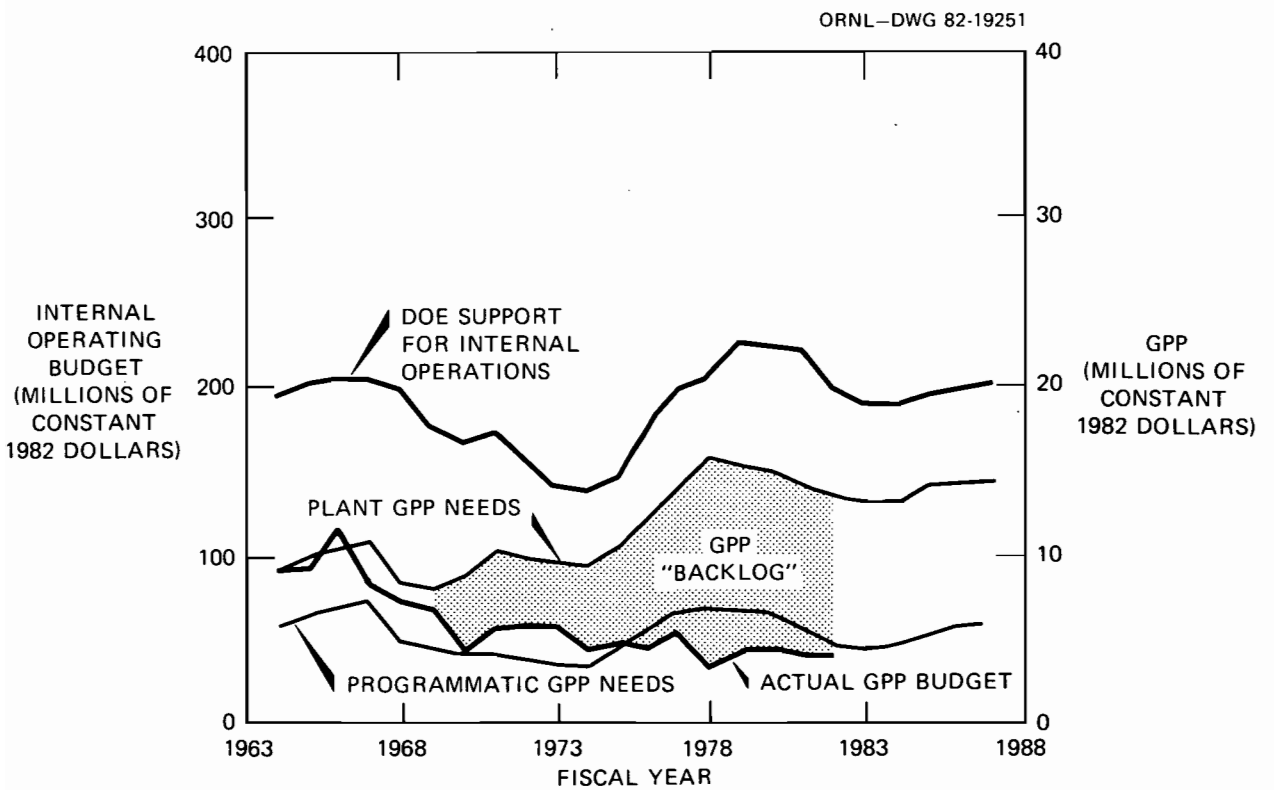


*Fig. 16. General plant projects needs, funding, and backlog.*

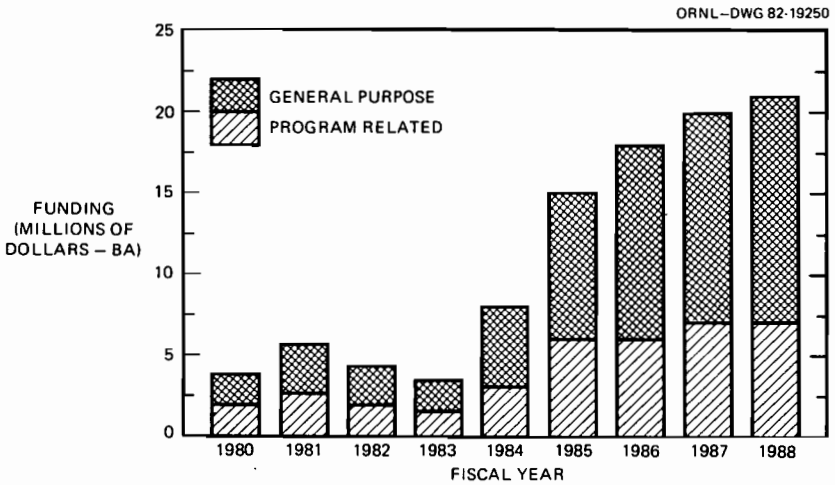


*Fig. 17. Funding for general plant projects.*

Laboratory to eliminate its GPP backlog by around FY 2000.

## MGPF Funding Goals

The ORNL Facilities Condition Summary, FY 1984–FY 1988, Table 16, identifies approximately $230 million (FY 1984 dollars) of general purpose facilities deficiencies that should have corrective actions initiated during the planning period. It is estimated that approximately $100 million of the total could be eliminated through GPP funding; $130 million would be handled most cost effectively through line-item projects. Table 17 lists the projects requiring action. The two projects for FY 1983 have received DOE funding approval. The listings for FY 1984 and FY 1985 have been formally proposed to DOE; the listings for FY 1986 through FY 1988 are tentative projects. The facilities evaluation studies will provide the detailed evaluation of the needs and their magnitude so that specific projects can be identified for the FY 1986 through FY 1988 period. It is expected that this information could significantly alter the currently projected funding requirements.

As can be seen from the listings in Table 17, a large percentage (60%) of the costs is for utility restorations and upgrading. The remainder is devoted to replacing a portion of obsolete temporary buildings at ORNL. Forty percent of the total would go to ORNL at Y-12 for utility restorations.

## Programmatic Line Items (Including Nuclear Waste GPP)

Those programmatic line-item projects that require funding support during the planning period to accomplish the projected program mission are listed below in Table 18. Two groups of projects are shown. Those included under the heading "Funded projects" are projects that have received at least partial funding approval from DOE. The category of "Proposed projects" includes those that have not yet received any funding approval from DOE.

Figure 18 summarizes the annual funding requirements for both programmatic line-item projects and MGPF line-item projects. For the years FY 1980 through FY 1982, ORNL's actual funding support is shown. For FY 1983 through FY 1988, the remaining requirements for previously funded projects and the total requirements for all proposed projects are shown separately. The large funding needs for projects in FY 1987 and FY 1988 are associated with the Reprocessing Test Facility proposed to the Assistant Secretary for Nuclear Energy (see "Consolidated Fuel Reprocessing" under "Scientific and Technical Activities").

## General Purpose Equipment

A modest shortage of GPE funding over an extended period has resulted in a portion of the

**Table 17. MGPF[a] line-item projects, FY 1983–FY 1988**

| | Total estimated cost (millions of dollars—BA) |
|---|---|
| **Funded Projects[b]** | |
| FY 1983 | |
| Laboratory Emergency Response Center | 4.2 |
| Upgrade electrical service for research facilities (Y-12) | 5.0 |
| Total | 9.2 |
| **Proposed Projects** | |
| FY 1984 | |
| Cooling water facilities restoration (Y-12) | 4.0 |
| Total | 4.0 |
| FY 1985 | |
| Primary electrical distribution restoration | 2.0 |
| Improvements to existing sewage treatment system | 1.4 |
| Upgrade steam distribution system | 2.0 |
| Utilities restoration—piping systems (Y-12) | 7.6 |
| Central chilled water system restoration | 4.6 |
| Environmental and effluent monitoring systems replacement | 7.3 |
| Total | 24.9 |
| FY 1986[c] | |
| Laboratory research and support facility | 8.4 |
| Replace refrigeration equipment (Y-12) | 3.0 |
| Utilities restoration—electrical systems (Y-12) | 8.0 |
| Alternate water supply | 4.8 |
| Upgrade machine shop facilities | 5.8 |
| Total | 30.0 |
| FY 1987[c] | |
| Replace inadequate laboratory and office facilities | 15.6 |
| Replace two substations (Y-12) | 13.0 |
| Utilities restoration—piping systems (Y-12) | 6.4 |
| Total | 35.0 |
| FY 1988[c] | |
| Replace inadequate office facilities | 10.0 |
| Upgrade maintenance facilities | 8.0 |
| Replace various substations (Y-12) | 11.0 |
| Upgrade materials warehousing | 2.6 |
| Revise Bethel Valley Road and New Entry Road | 3.4 |
| Replace main reservoir | 5.0 |
| Total | 40.0 |

[a]Multiprogram general purpose facilities.

[b]Projects having at least partial funding approval from DOE.

[c]These projects have not been fully defined and are presented to indicate the approximate magnitude of the MGPF needs during the planning period. Specifics of the projects will be developed by the facilities evaluation studies, which will be ongoing in FY 1983–1984.

**Table 18. Programmatic line-item projects**

| | Total estimated cost (millions of dollars—BA) |
|---|---|
| **Funded projects**[a] | |
| FY 1982 and prior years | |
| Integrated Equipment Test Facility | 16.0 |
| Consolidated Edison uranium solidification | 17.0 |
| EBT–Proof-of-Principle Experiment | 116.4[b] |
| Large Coil Test Facility | 20.0[c] |
| Radioactive waste facilities improvements | 21.3 |
| Teratogenic (Embryonic) Effect of Fossil-related Chemicals Laboratory | 1.0 |
| Accelerator improvements and modifications—HHIRF[d] | 0.5 |
| Radioactive Waste Program—GPP[e] | 0.8 |
| **Proposed projects** | |
| FY 1983 | |
| Hazardous Waste Incinerator Facility | 1.6 |
| Radioactive Waste Program—GPP | 2.0[f] |
| FY 1984 | |
| High-Temperature Materials Laboratory | 20.6 |
| Accelerator improvements and modifications—EN-Tandem | 0.4 |
| Accelerator and reactor improvements—HHIRF | 0.5 |
| HHIRF, phase II | 28.0 |
| ORELA[g] radiofrequency power system upgrade (AIM Project) | 0.5 |
| Energy Monitoring and Control System | 6.0 |
| FY 1985 | |
| Reprocessing Test Facility | 250.0 |
| Waste Collection Tanks Project | 35.0 |
| Human and Safety Instrumentation Laboratory | 3.0 |
| Upgrade air supply system genetics facility | 3.0 |
| Modifications to Component Flow Test Loop | 9.5 |
| Accelerator improvements and modifications—HHIRF | 0.5 |
| FY 1986 | |
| Chemical toxicology facilities | 16.3 |
| FY 1987 | |
| Toxic Substances Laboratory and Animal Facility | 27.7 |

[a]Projects having at least partial funding approval from DOE.

[b]Total estimated costs as contained in ORNL's April 1982 budget submission.

[c]Including capital equipment funds, the total estimated cost for the Large Coil Test Facility is $36.9 million.

[d]Holifield Heavy Ion Research Facility.

[e]General plant projects.

[f]Per year.

[g]Oak Ridge Electron Linear Accelerator.

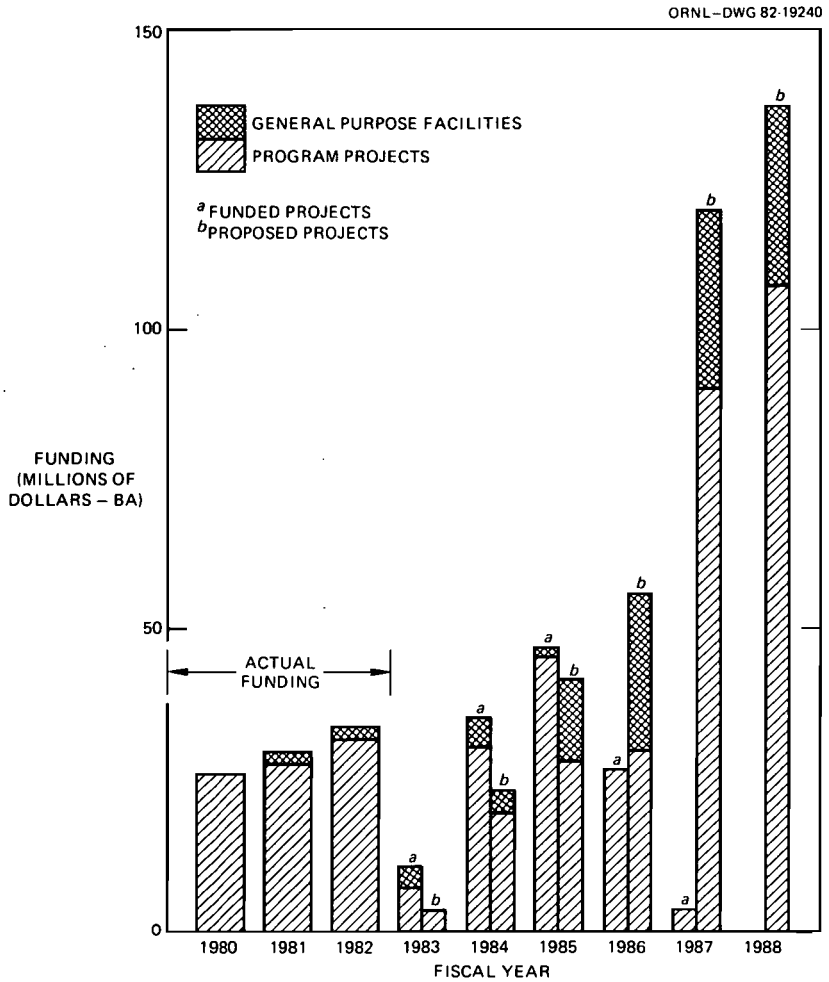


*Fig. 18. Line-item construction projects.*

Laboratory's equipment being obsolete and in need of replacement. The funding level required to maintain the existing inventory is approximately $7 million per year.

## In-House Energy Management Retrofit and Line-Item Projects

The funding goals of the energy management projects that have been identified for the planning period are shown in Table 19.

## *Impact on Programs of Failure to Achieve Goals*

The failure to achieve our future funding goals will have direct impacts on all of the research programs at the Laboratory. Examples of the effects on these are described below.

In the maintenance area, over 25% of the roofs of Laboratory buildings (those built in the late 1950s and 1960s) will require replacement during the planning period. This effort represents a major increase in roofing requirements, which are now coming due. Unfortunately this work on roofs is occurring simultaneously with reductions in Laboratory operating funds and the continued aging of obsolete buildings, equipment, and utilities. If this obsolesence is not adequately dealt with through other resources (e.g., GPP, MGPF, GPE), the increased maintenance and emergency repair requirement coupled with the roof work will result in a significant increase in the Laboratory's overhead rate and in reduced funds for research activities.

**Table 19. Funding goals for in-house energy management projects**

| | Project fiscal year | | | | | |
|---|---|---|---|---|---|---|
| | '83 | '84 | '85 | '86 | '87 | '88 |
| Total estimated cost of projects, millions of dollars | 1.5 | 6.0[a] | 2.0 | 2.0 | 2.0 | 1.5 |

[a]Includes Energy Monitoring and Control System.

As has been noted earlier, GPP is a major resource used in the renewal of the Laboratory as well as a primary means of responding to programmatic change in our research facilities. The continuation of the shortfall of the past ten years will shift the burden of facilities renewal to maintenance dollars where, because of the limitations on operating dollars, the solutions take the form of temporary fixes with little or no long-term benefit to the Laboratory. Response to programmatic change will be severely inhibited because proper modificants to existing facilities frequently cannot be accomplished with operating dollars.

ORNL's Solid State Division typifies the need to respond to programmatic change with GPP dollars. New research activities require the addition of space adjacent to the existing laboratories as well as some changes to the basic building support systems (power, heating, ventilating, and air conditioning, etc.). These changes are beyond the scope of noncapital modifications. If inadequate funds were provided, the research within the existing space would be severely hampered and the added space could not be provided.

The MGPF program at ORNL has addressed those facilities restoration projects that are beyond the scope of GPP. These focus primarily on badly needed utility system upgrades. One proposed project, the utilities restoration—piping systems (ORNL at Y-12), would replace key worn-out elements of various piping systems. In recent years a significant deterioration of these systems has occurred including: corrosion-related line ruptures, inoperable valves caused by gate or plug deterioration, 50 to 90% reduction in flow resulting from scaling, and structurally unsafe cooling towers caused by decomposition. These systems are crucial to the operations of the Medical Isotope Separation, Biological Sciences, Fission, Fusion, and Nuclear Regulatory Commission programs housed at Y-12. A failure in these systems can cause disruptions to program activities ranging from several hours in the case of minor failures to months in the case of loss of the cooling towers.

Failure to fund programmatic line items directly affects the associated programs through inability to perform the work as proposed. One example involving a new building is the High-Temperature Materials Laboratory (HTML).

Considerable progress has been made in organizing a High-Temperature Materials Program. However, the construction of the HTML and the consolidation of our research into that facility are crucial to the success of the program. The facility would provide both housing for the highly interactive groups working in this area and the appropriate laboratory space and new equipment in support of their activities. This combination would create a prime resource for researchers from all sectors including industry and universities.

A number of projects have been accomplished in the in-house energy management area. Many have been relatively small and with very short paybacks (i.e., three years). A series of larger and longer payback projects will have to be supported to continue to reduce energy-related operating cost to the Laboratory. One such project is the EMCS, which is estimated to save over $2 \times 10^{10}$ J (20 million BTU) per year. Other projects for ORNL buildings at Y-12 are projected to significantly reduce utility costs for the Biology Division. Currently, that division's utility costs have reached 31% ($4.6 million per year) of its

operating budget. Failure to achieve these reductions in utility costs will cause further reductions in funds available for research in already hard-pressed programs.

Electricity costs as a percentage of total operating budget (Fig. 19) will rise from about 2% in FY 1979 to close to 3% in FY 1983. While this trend is projected to moderate beyond FY 1983, it is apparent that effective energy management should be used as much as possible to minimize the consumption of research dollars in this area.

## *Automated Data Processing Requirements*

Planning at ORNL in the area of automated data processing focuses on the innovative use of contemporary computing capabilities for purposes of advancing the Laboratory's research and development. There is little research and development directed toward the improvement of computing capability for its own sake.

Currently, ORNL's computing services are provided by UCC-ND's Computer Sciences Division. In addition to serving ORNL, the Computer Sciences Division provides the computing services required by all other computer users within the UCC-ND organization [see organization chart (Fig. 11) of the Personnel Resources section]. Consequently, most of the major computing machinery is shared by many users throughout the facilities operated by UCC-ND.

In view of UCC's announcement (May 3, 1982) that it will not renew its operating contract with DOE, it has become necessary to consider how the change in contractor may affect the current computer services operation. An added factor is DOE's expressed preference for a multiple-contractor arrangement for the operation of the four major plants.

A committee has been established to examine the possible effects of the contractor change. The primary concern is how to best continue the services that are now provided by shared equipment and by core groups. A special concern is the determination of whether existing computing resources can be redistributed to provide separate contractors the administrative computing services that are now performed as a unified function.

## Technical Computing Requirements

Areas of changing technical computing at ORNL considered below include time-sharing, numerical cal-

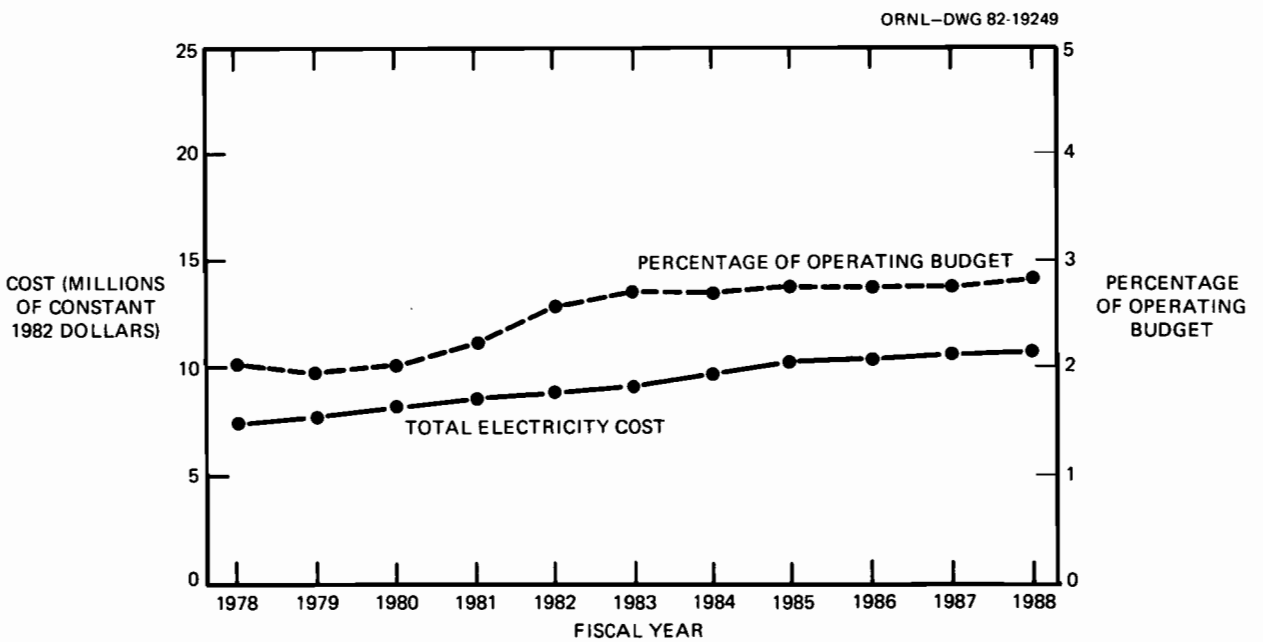


*Fig. 19. Electricity costs as a percentage of total operating budget.*

culations, computer-aided design, stand-alone computing, and high-speed data communications.

## Time-Sharing

In supporting research, one of the most useful computing developments has been the widespread availability of time-sharing capability based on a Digital Equipment Corporation KL-10 system. With over 2500 users currently, the demand for this system exceeds the available capacity, and priority is given to increasing the capacity.* A major acquisition (~$1.5M) for this purpose is planned in FY 1984, as detailed in the UCC-ND automated data processing (ADP) Long-Range Site Plan of March 22, 1982. In purchasing additional capability, we will seek modern and efficient equipment. However, it is crucial from a financial standpoint that expansions of the time-sharing system be compatible with our existing equipment.

## Numerical Calculations

The growth curve indicating the use of central computing facilities at ORNL has shown a flattening for the last two to three years, compared to the rather steady growth trend of the previous decade. One cause of this is that the real cost of computing has nearly doubled over a period of three years because of leasing requirements imposed by new federal regulations. The Laboratory's Computing Steering Committee projects that growth in the use of computing facilities will resume as leasing costs become reduced, despite the constrained budgets for Laboratory programs. A few segments of the Laboratory have extensive computer use, and, as a result, computing costs are a significant part of their controllable budgets. For most users, however, computing costs are negligible, and expansion of use can, and likely will, take place. However, the rate of growth is expected to be less than the historical trend of doubling every two years.

Some computer-intensive research and development programs at ORNL are limited by the lack of assured use of an advanced computer. Calculations that tend to be computer limited now include those relating to nuclear-reactor engineering, heat and mass transfer, hydrodynamics, and simulation of energy processes (such as synfuel production), fuel supplies (with varying degrees of aggregation), and environmental effects of energy production (such as $CO_2$ effects on climate). Additional areas of research will be affected when markedly advanced computing facilities become available. For several of the existing programs, calculations are now carried out on advanced machines (especially CRAY vector processors) at other institutions. Using the advanced computing facilities at these other institutions is beneficial but, obviously, imposes limitations. Although the capability of a high-speed computer is required for ORNL calculations in both science and engineering, the overall capacity of these advanced machines is so great as to exceed the needs of all users in Oak Ridge. Therefore, to be cost effective, ORNL will join with other national laboratories in sharing a high-speed computer at some selected central location. For maximum benefit, this computer should be of the "Class VII" type, the availability of which is expected to be announced in the next year or two.

The advantages in computing available with vector processors, current and future, depend upon programming practices and techniques that take advantage of the special efficiencies available. Our experience in these areas is limited. A study group has been organized to examine the mix of programs that use the current Oak Ridge computers most heavily and to determine requirements of these programs for conversion to vector processing.

Prior to about 1985 when an advanced high-speed computer could be made available directly to ORNL, there appear to be options for significantly expanding the capabilities of the existing system at modest cost. In particular, the use of an array processor that costs a few hundred thousand dollars might double the effective speed of one of the IBM 3033s. It is proposed to investigate this possibility as soon as a reliable array processor becomes available. Again, a study group has been established to identify the applications within the Laboratory's broad mix for which the use of an array processor would be most efficient; this option does not meet all the future computing requirements, but rather provides a limited and apparently cost-effective interim improvement over the current capabilities.

*An example of the expanding interest in this system (and in other user-oriented number and word processors) is the purchase of 257 terminals at ORNL during FY 1981.

### *Computer-Aided Design*

The Laboratory does not have its own engineering organization, but it makes extensive use of the groups within UCC-ND that provide these services (see organization chart in Fig. 11 of the "Personnel Resources" section). To help improve the efficiency of the engineering design process, the Laboratory has made a commitment to extensive use of computer-aided design techniques. Computer-aided design will also expedite the work of Laboratory divisions, especially the Instrumentation and Controls Division. These applications are requiring the purchase of specialized equipment including terminals and central processors. However, in the start-up phase, one of the IBM 3033s will be used as the central processor. The initial demand for computing time appears small enough so that it will not strongly affect other users of the central facility. Demands for software development will be minimized by the purchase of software systems that have been developed elsewhere.

### *Small Computers*

ORNL is also making use of the increasingly powerful minicomputers offered at attractive prices. We note that the high-energy physics community in the United States has moved increasingly toward stand-alone and interconnected devices like the Digital Equipment 11/780 (VAX). At ORNL, these systems will be used primarily for special applications such as data logging, systems control (as for physics experiments at accelerators), and experimental data analysis in near-real time. The costs of peripheral equipment duplication at ORNL will be minimized by the readily available high-speed transfer of information made possible by the communications system described in the next section. The additional costs in maintaining dispersed operating staffs (or computer operation by scientists and engineers) must be recognized.

Currently at ORNL, the Physics Division is testing a VAX plus a floating point system array processor for data analysis at the Holifield Heavy Ion Laboratory. We regard this application as a test, or demonstration, of a modern minicomputer system in the ORNL environment, and we expect our future plans to be influenced by the results.

### *High-Speed Data Communications System*

The Laboratory's computing capabilities are provided by a wide variety of systems, and the trend toward distributed computing can only continue. Thus, the need for high-speed communications is becoming more and more crucial. The current communications system and the plans for future changes are described in a document prepared especially for the users and managers of computing services (*UCC–ND Computer Sciences Two-Year Operational Plan for FY 1982–1983, May 1982*). The communication links in the existing system are mostly based on conventional telephone lines; a few high-speed telephone lines are used for the most demanding service. An improved communications system, based on the development of components and techniques used in cable television, is needed.

ORNL is therefore giving emphasis to the planning of high-speed data links that can provide vastly increased communication capabilities among the existing components of the computing network. Because of the mass production of equipment for cable television systems, the cost of the basic cable system is expected to be modest (~$400K). Furthermore, the same system can be used for transmitting video signals for teleconferencing and word-processing information.

The communication system has been designed to reach most Laboratory users, including those in Bear Creek Valley, and will be constructed over the next two years. Because the system provides only the communication links, it is necessary for the users to modify their equipment to take advantage of the expanded capabilities. Thus, a massive coordination task is required to maintain the needed standardization and accomplish the research and development objectives of individual users. Coordination groups have been established for this process.

## Current Equipment

Table 20 shows the major computer systems currently installed to serve the Oak Ridge complex.

**Table 20. Major computer systems serving the Oak Ridge complex**

| System description | Installation date |
|---|---|
| **ORNL** | |
| DEC KL10: 1024K-word memory, dual processor, five channels, eight disk drives, and two magnetic tape drives to collect and analyze data for the Fusion Energy Division | July 1976 |
| DEC KA10 plus SEL and PDP minicomputers to collect and analyze data at the Oak Ridge Electron Linear Accelerator | Apr. 1977 |
| DEC KL10: 1664K-word memory, four processors, nine channels, 19 disk drives, and two magnetic tape drives | Jan. 1977 |
| IBM 3033: 8MB memory and 12 channels | Nov. 1979 |
| IBM 3033: 8MB memory and 12 channels | Oct. 1979 |
| Combined equipment for the IBM 3033 systems: 107 disks, one mass-storage device, and 14 magnetic tape drives | |
| **ORGDP** | |
| IBM 1800 system to collect and analyze data at the Barrier Manufacturing Plant | May 1969 |
| IBM 360/195: 4MB memory, seven channels, 40 disks, three drums, 17 magnetic tape drives, and one mass-storage device | Nov. 1972 |
| IBM 370/155: 4MB memory, six channels | Feb. 1973 |
| IBM 4341: 4MB memory, six channels | Jan. 1981 |
| Combined equipment for the IBM 155 and the IBM 4341 includes 26 disk drives and four magnetic tape drives | |
| DEC 2020 system provides project tracking and administrative control capability to the Operating Contractor's Project Office for the Gas Centrifuge Enrichment Project | Apr. 1980 |
| **Y-12** | |
| CDC 3300: 80K-word memory, 16 disk drives, and six magnetic tape drives | May 1968 |
| Dual DEC 2040/2060 computer system: field stations to track and verify special material movements within accountability areas for the Y-12 Plant | July 1979 |
| IBM 4341: 4MB memory, six channels, 22 disk drives, and eight magnetic tape drives | May 1981 |

# APPENDIX– RESOURCE PROJECTIONS

**Table A.1. Overall Laboratory summary**

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **Funding summary** (Millions of Dollars) | | | | | | | | | | | | | | |
| DOE Effort | | | | | | | | | | | | | | |
| Operating | 271.8 | 276.1 | 259.4 | 274.3 | 304.3 | 293.9 | 301.5 | 295.4 | 310.3 | 304.6 | 316.6 | 312.4 | 318.8 | 314.5 |
| Work for Others | | | | | | | | | | | | | | |
| Operating | 59.1 | 58.6 | 57.1 | 58.7 | 58.1 | 55.4 | 59.8 | 57.0 | 61.0 | 58.3 | 61.6 | 58.9 | 62.2 | 59.4 |
| Total Laboratory | | | | | | | | | | | | | | |
| Operating | 330.8 | 334.7 | 316.5 | 333.0 | 362.4 | 349.3 | 361.3 | 352.5 | 371.3 | 362.8 | 378.3 | 371.3 | 381.0 | 373.9 |
| Capital Equipment | 23.6 | | 28.5 | | 29.4 | | 28.0 | | 28.5 | | 29.1 | | 29.2 | |
| Program Construction | 31.8 | | 7.2 | | 31.2 | | 45.9 | | 27.0 | | 4.2 | | 0.0 | |
| General Purpose Facilities | 2.6 | | 3.6 | | 4.7 | | 0.9 | | 0.0 | | 0.0 | | 0.0 | |
| General Plant Projects | 4.3 | | 3.5[b] | | 8.0 | | 15.0 | | 18.0 | | 20.0 | | 21.0 | |
| General Purpose Equipment | 4.1 | | 6.3 | | 6.6 | | 7.0 | | 7.0 | | 7.0 | | 7.0 | |
| Total Laboratory Funding | 397.2 | | 365.6 | | 442.3 | | 458.1 | | 451.8 | | 438.6 | | 438.2 | |
| Proposed Program Construction | 0.0 | | 3.6 | | 34.4 | | 43.6 | | 45.0 | | 90.0 | | 107.0 | |
| Proposed GPF | 0.0 | | 0.0 | | 4.0 | | 13.5 | | 26.0 | | 30.0 | | 30.0 | |

**Personnel summary** (FTEs)

| | FY 1982 | FY 1983 | FY 1984 | FY 1985 | FY 1986 | FY 1987 | FY 1988 |
|---|---|---|---|---|---|---|---|
| Direct | | | | | | | |
| Direct Effort[c] | 1716.9 | 1586.0 | 1572.1 | 1586.8 | 1620.5 | 1639.8 | 1661.2 |
| Work for Others | 451.0 | 457.9 | 420.3 | 432.3 | 442.1 | 443.9 | 445.8 |
| Total Direct | 2167.9 | 2043.9 | 1992.4 | 2019.1 | 2062.6 | 2083.7 | 2107.0 |
| Indirect | 2557.1 | 2381.1 | 2407.6 | 2413.9 | 2437.4 | 2466.3 | 2493.0 |
| Total Laboratory Personnel | 4725.0 | 4425.0 | 4400.0 | 4433.0 | 4500.0 | 4550.0 | 4600.0 |

[a]Escalation factors from FY 1982 to FY 1983 and from FY 1983 to FY 1984 are both 10%. Figures for FY 1985 through FY 1988 are in constant FY 1984 dollars.

[b]$3.5 million represents DOE guidance for FY 1983 GPP funding. $6.5 million in FY 1983 and the listed amounts for FY 1984 through FY 1988 are required to initiate and continue the facilities restoration effort described.

[c]Includes isotopes staff (54 FTEs) who are not charged directly to research programs.

**Table A.2. Resources by subprogram**

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **Assistant Secretary for Fossil Energy** | | | | | | | | | | | | | | |
| Total Operating | 11.7 | 13.8 | 8.8 | 12.1 | 17.0 | 15.8 | 19.2 | 18.6 | 20.8 | 20.5 | 21.4 | 21.4 | 21.4 | 21.4 |
| Capital Equipment | 0.2 | | 0.0 | | 1.0 | | 1.1 | | 1.2 | | 1.3 | | 1.3 | |
| Total Asst Secretary | 11.9 | | 8.8 | | 18.0 | | 20.4 | | 21.9 | | 22.7 | | 22.7 | |
| **Assistant Secretary for Nuclear Energy** | | | | | | | | | | | | | | |
| Total Operating | 51.3 | 46.0 | 42.4 | 43.1 | 47.2 | 46.5 | 50.5 | 49.6 | 54.3 | 53.0 | 58.5 | 58.5 | 59.4 | 59.4 |
| Capital Equipment | 4.7 | | 4.5 | | 6.6 | | 6.6 | | 6.6 | | 7.1 | | 7.1 | |
| Total Asst Secretary | 56.0 | | 46.9 | | 53.9 | | 57.1 | | 60.8 | | 65.6 | | 66.5 | |
| **AS for Conservation and Renewable Energy** | | | | | | | | | | | | | | |
| Total Operating | 27.6 | 33.1 | 17.8 | 32.9 | 19.3 | 22.9 | 18.2 | 18.3 | 18.3 | 18.3 | 18.3 | 18.3 | 18.3 | 18.3 |
| Capital Equipment | 0.6 | | 0.8 | | 1.2 | | 0.4 | | 0.4 | | 0.4 | | 0.4 | |
| Total Asst Secretary | 28.1 | | 18.5 | | 20.5 | | 18.6 | | 18.7 | | 18.7 | | 18.7 | |
| **Office of Policy, Planning & Analysis** | | | | | | | | | | | | | | |
| Total Operating | 0.2 | 0.3 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |

[a] Escalation factors from FY 1982 to FY 1983 and from FY 1983 to FY 1984 are both 10%. Figures for FY 1985 through FY 1988 are in constant FY 1984 dollars.

Table A.2 (continued)

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **Office of Energy Research** | | | | | | | | | | | | | | |
| Total Operating | 135.9 | 137.1 | 146.8 | 142.6 | 178.5 | 165.5 | 172.0 | 167.7 | 173.5 | 169.2 | 173.8 | 169.5 | 173.8 | 169.5 |
| Capital Equipment | 16.0 | | 20.1 | | 17.5 | | 17.4 | | 17.8 | | 17.9 | | 18.0 | |
| Construction | 20.9 | | 0.0 | | 25.0 | | 45.0 | | 27.0 | | 4.2 | | 0.0 | |
| Total Asst Secretary | 172.8 | | 166.9 | | 221.0 | | 234.4 | | 218.3 | | 195.9 | | 191.8 | |
| **Assistant Secretary for Defense Programs** | | | | | | | | | | | | | | |
| Total Operating | 21.3 | 22.5 | 24.0 | 22.8 | 23.8 | 23.8 | 23.6 | 23.3 | 25.0 | 25.0 | 25.0 | 25.1 | 25.3 | 25.2 |
| Capital Equipment | 0.6 | | 1.4 | | 1.7 | | 0.9 | | 1.0 | | 0.9 | | 0.9 | |
| Construction | 10.9 | | 7.2 | | 6.2 | | 0.9 | | 0.0 | | 0.0 | | 0.0 | |
| Total Asst Secretary | 32.7 | | 32.6 | | 31.7 | | 25.4 | | 26.0 | | 26.0 | | 26.3 | |
| **AS for Env.Protection,Safety & Emerg. Prep** | | | | | | | | | | | | | | |
| Total Operating | 5.9 | 6.7 | 4.1 | 4.6 | 4.1 | 4.1 | 4.1 | 4.1 | 4.1 | 4.1 | 4.1 | 4.1 | 4.1 | 4.1 |
| Capital Equipment | 0.0 | | 0.3 | | 0.2 | | 0.3 | | 0.3 | | 0.3 | | 0.3 | |
| Total Asst Secretary | 5.9 | | 4.5 | | 4.4 | | 4.4 | | 4.4 | | 4.4 | | 4.4 | |
| **Federal Energy Regulatory Commission** | | | | | | | | | | | | | | |
| Total Operating | 0.0 | 0.0 | 0.7 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |

Table A.2 (continued)

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **Economic Regulatory Administration** | | | | | | | | | | | | | | |
| Total Operating | 0.0 | 0.4 | 0.1 | 0.2 | 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 | 9.7 | 7.2 | 8.0 | 9.8 | 9.0 | 9.0 | 9.0 | 9.0 | 9.0 | 9.0 | 9.0 | 9.0 | 9.0 | 9.0 |
| Capital Equipment | 0.0 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | |
| Total Asst Secretary | 9.7 | | 8.1 | | 9.1 | | 9.1 | | 9.1 | | 9.1 | | 9.1 | |
| **Asst. Sec. for Management & Administration** | | | | | | | | | | | | | | |
| 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 |
| Capital Equipment | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | |
| Total Asst Secretary | 0.9 | | 0.9 | | 0.9 | | 0.9 | | 0.9 | | 0.9 | | 0.9 | |
| **DOE CONTRACTORS & OPERATIONS OFFICES** | | | | | | | | | | | | | | |
| Total Operating | 7.5 | 8.0 | 5.8 | 4.8 | 3.8 | 4.8 | 3.4 | 3.4 | 3.9 | 3.9 | 5.0 | 5.0 | 6.0 | 6.0 |
| **Total DOE Programs** | | | | | | | | | | | | | | |
| Total Operating | 271.8 | 276.1 | 259.4 | 274.3 | 304.3 | 293.9 | 301.5 | 295.4 | 310.3 | 304.6 | 316.6 | 312.4 | 318.8 | 314.5 |
| Capital Equipment | 22.3 | | 27.4 | | 28.4 | | 27.0 | | 27.5 | | 28.1 | | 28.2 | |
| Construction | 31.8 | | 7.2 | | 31.2 | | 45.9 | | 27.0 | | 4.2 | | 0.0 | |
| Total DOE Programs | 325.8 | | 294.0 | | 363.9 | | 374.5 | | 364.8 | | 348.9 | | 347.0 | |

Table A.2 (continued)

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| NUCLEAR REGULATORY COMMISSION | | | | | | | | | | | | | | |
| Total Operating | 30.6 | 30.1 | 29.0 | 30.5 | 30.2 | 27.5 | 30.2 | 27.5 | 30.2 | 27.5 | 30.2 | 27.5 | 30.2 | 27.5 |
| Capital Equipment | 1.3 | | 0.9 | | 0.8 | | 0.8 | | 0.8 | | 0.8 | | 0.8 | |
| Total Program | 31.9 | | 30.0 | | 31.1 | | 31.1 | | 31.1 | | 31.1 | | 31.1 | |
| DEPARTMENT OF DEFENSE | | | | | | | | | | | | | | |
| Total Operating | 4.0 | 4.0 | 4.9 | 4.9 | 4.6 | 4.6 | 4.7 | 4.7 | 4.9 | 4.9 | 5.1 | 5.1 | 5.2 | 5.2 |
| Capital Equipment | 0.1 | | 0.1 | | 0.1 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| Total Program | 4.1 | | 4.9 | | 4.6 | | 4.8 | | 5.0 | | 5.1 | | 5.3 | |
| OTHER FEDERAL AGENCIES | | | | | | | | | | | | | | |
| Total Operating | 20.0 | 20.0 | 18.9 | 19.2 | 18.8 | 18.8 | 19.3 | 19.3 | 19.7 | 19.7 | 20.0 | 20.0 | 20.3 | 20.3 |
| NONFEDERAL AGENCIES | | | | | | | | | | | | | | |
| Total Operating | 4.4 | 4.4 | 4.2 | 4.2 | 4.5 | 4.5 | 5.5 | 5.5 | 6.2 | 6.2 | 6.3 | 6.3 | 6.3 | 6.3 |
| Capital Equipment | 0.0 | | 0.0 | | 0.0 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | |
| Total Programs | 4.4 | | 4.3 | | 4.6 | | 5.6 | | 6.3 | | 6.4 | | 6.4 | |

Table A.2 (continued)

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| Total Work for Others | | | | | | | | | | | | | | |
| Total Operating | 59.1 | 58.6 | 57.1 | 58.7 | 58.1 | 55.4 | 59.8 | 57.0 | 61.0 | 58.3 | 61.6 | 58.9 | 62.2 | 59.4 |
| Capital Equipment | 1.4 | | 1.1 | | 0.9 | | 1.0 | | 1.0 | | 1.0 | | 1.0 | |
| Total WFO Programs | 60.4 | | 58.1 | | 59.1 | | 60.8 | | 62.0 | | 62.6 | | 63.2 | |
| General Purpose Fac. | 2.6 | | 3.6 | | 4.7 | | 0.9 | | 0.0 | | 0.0 | | 0.0 | |
| General Purpose Proj. | 4.3 | | 3.5[b] | | 8.0 | | 15.0 | | 18.0 | | 20.0 | | 21.0 | |
| General Purpose Equip. | 4.1 | | 6.3 | | 6.6 | | 7.0 | | 7.0 | | 7.0 | | 7.0 | |
| Total Lab. Funding | 397.2 | | 365.6 | | 442.3 | | 458.1 | | 451.8 | | 438.6 | | 438.2 | |
| Proposed Prg. Const. | 0.0 | | 3.6 | | 34.4 | | 43.6 | | 45.0 | | 90.0 | | 107.0 | |
| Proposed GPF | 0.0 | | 0.0 | | 4.0 | | 13.5 | | 26.0 | | 30.0 | | 30.0 | |

[b] $3.5 million represents DOE guidance for FY 1983 GPP funding. $6.5 million is required to initiate the facilities restoration effort described.

Table A.2 (continued)

| | FY 1982 | FY 1983 | FY 1984 | FY 1985 | FY 1986 | FY 1987 | FY 1988 |
|---|---|---|---|---|---|---|---|
| **Assistant Secretary for Fossil Energy** | | | | | | | |
| Direct Personnel | 82.8 | 59.4 | 69.5 | 79.4 | 87.5 | 93.5 | 93.5 |
| **Assistant Secretary for Nuclear Energy** | | | | | | | |
| Direct Personnel | 300.8 | 276.0 | 256.8 | 255.6 | 271.2 | 288.4 | 293.9 |
| **AS for Conservation and Renewable Energy** | | | | | | | |
| Direct Personnel | 115.7 | 99.8 | 74.6 | 67.0 | 67.0 | 67.0 | 67.0 |
| **Office of Policy, Planning & Analysis** | | | | | | | |
| Direct Personnel | 0.3 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 |
| **Office of Energy Research** | | | | | | | |
| Direct Personnel | 889.4 | 861.2 | 862.6 | 873.6 | 878.6 | 878.6 | 878.8 |
| **Assistant Secretary for Defense Programs** | | | | | | | |
| Direct Personnel | 170.7 | 147.1 | 175.2 | 181.6 | 183.5 | 174.6 | 180.3 |
| **AS for Env.Protection,Safety & Emerg. Prep** | | | | | | | |
| Direct Personnel | 40.0 | 28.3 | 21.0 | 21.0 | 21.0 | 21.0 | 21.0 |
| **Federal Energy Regulatory Commission** | | | | | | | |
| Direct Personnel | 0.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

Table A.2 (continued)

| | FY 1982 | FY 1983 | FY 1984 | FY 1985 | FY 1986 | FY 1987 | FY 1988 |
|---|---|---|---|---|---|---|---|
| Economic Regulatory Administration | | | | | | | |
| Direct Personnel | 0.9 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Energy Information Adminstration | | | | | | | |
| Direct Personnel | 11.0 | 22.5 | 30.0 | 30.0 | 30.0 | 30.0 | 30.0 |
| Asst. Sec. for Management & Administration | | | | | | | |
| Direct Personnel | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| DOE CONTRACTORS & OPERATIONS OFFICES | | | | | | | |
| Direct Personnel | 51.3 | 33.3 | 25.0 | 21.2 | 24.3 | 29.3 | 39.3 |
| Total DOE Programs[c] | | | | | | | |
| Direct Personnel | 1716.9 | 1586.0 | 1572.1 | 1586.8 | 1620.5 | 1639.8 | 1661.2 |
| NUCLEAR REGULATORY COMMISSION | | | | | | | |
| Direct Personnel | 188.7 | 194.9 | 170.5 | 170.5 | 170.5 | 170.5 | 170.5 |
| DEPARTMENT OF DEFENSE | | | | | | | |
| Direct Personnel | 40.4 | 45.0 | 42.0 | 42.8 | 43.8 | 43.8 | 44.8 |
| OTHER FEDERAL AGENCIES | | | | | | | |
| Direct Personnel | 183.4 | 179.8 | 169.2 | 172.5 | 174.8 | 176.6 | 177.5 |

[c] Includes Isotopes Staff (54 FTEs) who are not charged directly to research programs.

Table A.2 (continued)

| | FY 1982 | FY 1983 | FY 1984 | FY 1985 | FY 1986 | FY 1987 | FY 1988 |
|---|---|---|---|---|---|---|---|
| NONFEDERAL AGENCIES | | | | | | | |
| Direct Personnel | 38.5 | 38.2 | 38.6 | 46.5 | 53.0 | 53.0 | 53.0 |
| Total Work for Others | | | | | | | |
| Direct Personnel | 451.0 | 457.9 | 420.3 | 432.3 | 442.1 | 443.9 | 445.8 |
| Total Direct Personnel | 2167.9 | 2043.9 | 1992.4 | 2019.1 | 2062.6 | 2083.7 | 2107.0 |
| Total Indirect Personnel | 2557.1 | 2381.1 | 2407.6 | 2413.9 | 2437.4 | 2466.3 | 2493.0 |
| Total Laboratory Personnel | 4725.0 | 4425.0 | 4400.0 | 4433.0 | 4500.0 | 4550.0 | 4600.0 |

**Table A.2 (continued)**

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **Assistant Secretary for Fossil Energy** | | | | | | | | | | | | | | |
| **AA05 Advanced Environmental Control Tech** | | | | | | | | | | | | | | |
| Internal Operating | | 0.2 | | 0.0 | | 0.7 | | 0.9 | | 1.0 | | 1.0 | | 1.0 |
| Procurement | | 0.0 | | 0.0 | | 1.5 | | 1.9 | | 2.1 | | 2.1 | | 2.1 |
| Total Operating | 0.0 | 0.2 | 0.0 | 0.0 | 3.0 | 2.2 | 2.8 | 2.8 | 3.1 | 3.0 | 3.2 | 3.2 | 3.2 | 3.2 |
| Capital Equipment | 0.0 | | 0.0 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | |
| Total Activity | 0.0 | | 0.0 | | 3.1 | | 2.9 | | 3.1 | | 3.2 | | 3.2 | |
| Direct Personnel | 2.1 | | 0.3 | | 5.0 | | 6.5 | | 7.1 | | 7.5 | | 7.5 | |
| **AA15 Advanced Research & Technology Dev** | | | | | | | | | | | | | | |
| Internal Operating | | 4.3 | | 4.4 | | 5.9 | | 6.1 | | 6.8 | | 7.2 | | 7.2 |
| Procurement | | 3.0 | | 4.4 | | 1.8 | | 2.1 | | 2.3 | | 2.3 | | 2.3 |
| Total Operating | 8.6 | 7.3 | 6.7 | 8.8 | 7.9 | 7.7 | 8.5 | 8.2 | 9.2 | 9.1 | 9.5 | 9.5 | 9.5 | 9.5 |
| Capital Equipment | 0.2 | | 0.0 | | 0.4 | | 0.4 | | 0.4 | | 0.5 | | 0.5 | |
| Total Activity | 8.8 | | 6.7 | | 8.3 | | 8.9 | | 9.6 | | 10.0 | | 10.0 | |
| Direct Personnel | 37.5 | | 34.5 | | 38.0 | | 39.8 | | 44.1 | | 46.6 | | 46.6 | |
| **AA25 Liquefaction** | | | | | | | | | | | | | | |
| Internal Operating | | 1.2 | | 1.4 | | 0.8 | | 0.9 | | 1.0 | | 1.0 | | 1.0 |
| Procurement | | 0.0 | | 0.1 | | 0.0 | | 0.1 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 1.3 | 1.2 | 0.7 | 1.5 | 0.7 | 0.8 | 0.8 | 0.9 | 1.0 | 1.0 | 1.1 | 1.1 | 1.1 | 1.1 |
| Capital Equipment | 0.1 | | 0.0 | | 0.0 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | |
| Total Activity | 1.4 | | 0.7 | | 0.7 | | 0.9 | | 1.1 | | 1.1 | | 1.1 | |
| Direct Personnel | 11.2 | | 13.1 | | 5.5 | | 6.3 | | 6.9 | | 7.3 | | 7.3 | |

Table A.2 (continued)

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **AA35 Combustion Systems** | | | | | | | | | | | | | | |
| Internal Operating | | 1.1 | | 0.1 | | 0.0 | | 0.4 | | 0.4 | | 0.4 | | 0.4 |
| Procurement | | 0.6 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | -0.7 | 1.6 | 0.0 | 0.1 | 0.0 | 0.0 | 0.5 | 0.4 | 0.4 | 0.4 | 0.5 | 0.5 | 0.5 | 0.5 |
| Direct Personnel | 10.8 | | 0.9 | | 0.0 | | 3.0 | | 3.3 | | 3.5 | | 3.5 | |
| **AA55 Heat Engines and Heat Recovery** | | | | | | | | | | | | | | |
| Internal Operating | | 0.8 | | 0.1 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.6 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.0 | 1.4 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 7.5 | | 1.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| **AA75 Mines Research & Development** | | | | | | | | | | | | | | |
| Internal Operating | | 0.0 | | 0.0 | | 0.0 | | 0.2 | | 0.2 | | 0.2 | | 0.2 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Direct Personnel | 0.0 | | 0.0 | | 0.0 | | 1.5 | | 1.6 | | 1.7 | | 1.7 | |

**Table A.2 (continued)**

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **AA85 Surface Coal Gasification** | | | | | | | | | | | | | | |
| Internal Operating | | 1.2 | | 0.9 | | 3.3 | | 3.3 | | 3.6 | | 4.0 | | 4.0 |
| Procurement | | 0.2 | | 0.4 | | 1.7 | | 2.6 | | 2.8 | | 2.7 | | 2.7 |
| Total Operating | 2.0 | 1.5 | 1.1 | 1.3 | 5.3 | 5.0 | 6.0 | 5.9 | 6.5 | 6.4 | 6.7 | 6.7 | 6.7 | 6.7 |
| Capital Equipment | 0.0 | | 0.0 | | 0.5 | | 0.6 | | 0.6 | | 0.6 | | 0.6 | |
| Total Activity | 2.0 | | 1.1 | | 5.8 | | 6.6 | | 7.1 | | 7.4 | | 7.4 | |
| Direct Personnel | 10.2 | | 7.6 | | 20.0 | | 20.0 | | 22.0 | | 24.4 | | 24.4 | |
| **AA COAL** | | | | | | | | | | | | | | |
| Internal Operating | | 8.9 | | 7.0 | | 10.6 | | 11.8 | | 13.0 | | 13.9 | | 13.9 |
| Procurement | | 4.3 | | 4.9 | | 5.0 | | 6.6 | | 7.2 | | 7.3 | | 7.3 |
| Total Operating | 11.3 | 13.3 | 8.5 | 11.9 | 16.8 | 15.7 | 19.0 | 18.3 | 20.5 | 20.2 | 21.2 | 21.2 | 21.2 | 21.2 |
| Capital Equipment | 0.2 | | 0.0 | | 1.0 | | 1.1 | | 1.2 | | 1.3 | | 1.3 | |
| Total Program | 11.5 | | 8.5 | | 17.8 | | 20.1 | | 21.6 | | 22.4 | | 22.4 | |
| Direct Personnel | 79.3 | | 57.4 | | 68.5 | | 77.1 | | 85.0 | | 91.0 | | 91.0 | |
| **AC15 Enhanced Oil Recovery** | | | | | | | | | | | | | | |
| Internal Operating | | 0.1 | | 0.1 | | 0.1 | | 0.2 | | 0.3 | | 0.3 | | 0.3 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.1 | 0.1 | 0.1 | 0.1 | 0.2 | 0.1 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| Direct Personnel | 0.8 | | 1.0 | | 1.0 | | 2.3 | | 2.5 | | 2.5 | | 2.5 | |

Table A.2 (continued)

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **AC PETROLEUM** | | | | | | | | | | | | | | |
| Internal Operating | | 0.1 | | 0.1 | | 0.1 | | 0.2 | | 0.3 | | 0.3 | | 0.3 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.1 | 0.1 | 0.1 | 0.1 | 0.2 | 0.1 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| Direct Personnel | 0.8 | | 1.0 | | 1.0 | | 2.3 | | 2.5 | | 2.5 | | 2.5 | |
| **CG01 Federal Leasing** | | | | | | | | | | | | | | |
| Internal Operating | | 0.1 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.1 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 1.1 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| **CG MULTI-RESOURCE** | | | | | | | | | | | | | | |
| Internal Operating | | 0.1 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.1 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 1.1 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |

**Table A.2 (continued)**

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **CH02 Project Devel Feasibility Studies** | | | | | | | | | | | | | | |
| Internal Operating | | 0.2 | | 0.1 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.3 | 0.2 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 1.6 | | 1.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| **CH ALTERNATE FUELS PRODUCTION** | | | | | | | | | | | | | | |
| Internal Operating | | 0.2 | | 0.1 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.3 | 0.2 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 1.6 | | 1.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| **Assistant Secretary for Fossil Energy** | | | | | | | | | | | | | | |
| Internal Operating | | 9.4 | | 7.2 | | 10.7 | | 12.0 | | 13.3 | | 14.2 | | 14.1 |
| Procurement | | 4.5 | | 4.9 | | 5.1 | | 6.6 | | 7.2 | | 7.3 | | 7.3 |
| Total Operating | 11.7 | 13.8 | 8.8 | 12.1 | 17.0 | 15.8 | 19.2 | 18.6 | 20.8 | 20.5 | 21.4 | 21.4 | 21.4 | 21.4 |
| Capital Equipment | 0.2 | | 0.0 | | 1.0 | | 1.1 | | 1.2 | | 1.3 | | 1.3 | |
| Total Asst Secretary | 11.9 | | 8.8 | | 18.0 | | 20.4 | | 21.9 | | 22.7 | | 22.7 | |
| Direct Personnel | 82.8 | | 59.4 | | 69.5 | | 79.4 | | 87.5 | | 93.5 | | 93.5 | |

Table A.2 (continued)

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **Assistant Secretary for Nuclear Energy** | | | | | | | | | | | | | | |
| **AE20 Space and Terrestrial Applications** | | | | | | | | | | | | | | |
| Internal Operating | | 1.9 | | 5.1 | | 4.1 | | 3.7 | | 3.8 | | 3.8 | | 3.8 |
| Procurement | | 0.8 | | 0.4 | | 0.4 | | 0.4 | | 0.3 | | 0.3 | | 0.3 |
| Total Operating | 2.7 | 2.7 | 5.5 | 5.5 | 4.5 | 4.5 | 4.1 | 4.1 | 4.1 | 4.1 | 4.1 | 4.1 | 4.1 | 4.1 |
| Capital Equipment | 0.1 | | 0.4 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | |
| Total Activity | 2.7 | | 5.9 | | 4.6 | | 4.2 | | 4.2 | | 4.2 | | 4.2 | |
| Direct Personnel | 16.0 | | 30.0 | | 20.0 | | 19.0 | | 19.0 | | 19.0 | | 19.0 | |
| **AE ADVANCED NUCLEAR SYSTEMS** | | | | | | | | | | | | | | |
| Internal Operating | | 1.9 | | 5.1 | | 4.1 | | 3.7 | | 3.8 | | 3.8 | | 3.8 |
| Procurement | | 0.8 | | 0.4 | | 0.4 | | 0.4 | | 0.3 | | 0.3 | | 0.3 |
| Total Operating | 2.7 | 2.7 | 5.5 | 5.5 | 4.5 | 4.5 | 4.1 | 4.1 | 4.1 | 4.1 | 4.1 | 4.1 | 4.1 | 4.1 |
| Capital Equipment | 0.1 | | 0.4 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | |
| Total Program | 2.7 | | 5.9 | | 4.6 | | 4.2 | | 4.2 | | 4.2 | | 4.2 | |
| Direct Personnel | 16.0 | | 30.0 | | 20.0 | | 19.0 | | 19.0 | | 19.0 | | 19.0 | |
| **AF05 Fuel Cycle Research & Development** | | | | | | | | | | | | | | |
| Internal Operating | | 15.3 | | 14.0 | | 16.0 | | 16.5 | | 18.5 | | 22.0 | | 24.5 |
| Procurement | | 4.3 | | 3.0 | | 4.0 | | 6.5 | | 7.5 | | 8.0 | | 5.5 |
| Total Operating | 24.6 | 19.6 | 17.9 | 17.0 | 20.9 | 20.0 | 23.9 | 23.0 | 27.2 | 26.0 | 30.0 | 30.0 | 30.0 | 30.0 |
| Capital Equipment | 3.0 | | 3.0 | | 4.0 | | 4.0 | | 4.0 | | 5.0 | | 5.0 | |
| Total Activity | 27.6 | | 20.9 | | 24.9 | | 27.9 | | 31.2 | | 35.0 | | 35.0 | |
| Proposed Construction | 0.0 | | 0.0 | | 0.0 | | 5.0 | | 15.0 | | 50.0 | | 100.0 | |
| Direct Personnel | 130.7 | | 111.4 | | 100.0 | | 101.0 | | 114.0 | | 130.0 | | 130.0 | |

**Table A.2 (continued)**

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **AF15 Liquid Metal Fast Breeder** | | | | | | | | | | | | | | |
| Internal Operating | | 10.4 | | 9.9 | | 11.2 | | 12.1 | | 12.1 | | 12.1 | | 12.1 |
| Procurement | | 0.8 | | 1.4 | | 1.3 | | 0.8 | | 0.8 | | 0.8 | | 0.8 |
| Total Operating | 12.1 | 11.2 | 9.7 | 11.3 | 12.3 | 12.5 | 12.9 | 12.9 | 12.9 | 12.9 | 12.9 | 12.9 | 12.9 | 12.9 |
| Capital Equipment | 0.6 | | 0.0 | | 0.6 | | 0.5 | | 0.5 | | 0.5 | | 0.5 | |
| Total Activity | 12.7 | | 9.7 | | 12.9 | | 13.4 | | 13.4 | | 13.4 | | 13.4 | |
| Direct Personnel | 84.2 | | 74.0 | | 76.3 | | 77.0 | | 77.0 | | 77.0 | | 77.0 | |
| **AF BREEDER REACTOR SYSTEMS** | | | | | | | | | | | | | | |
| Internal Operating | | 25.7 | | 23.9 | | 27.2 | | 28.6 | | 30.6 | | 34.1 | | 36.6 |
| Procurement | | 5.1 | | 4.4 | | 5.3 | | 7.3 | | 8.3 | | 8.8 | | 6.3 |
| Total Operating | 36.7 | 30.8 | 27.6 | 28.3 | 33.2 | 32.5 | 36.8 | 35.9 | 40.1 | 38.9 | 42.9 | 42.9 | 42.9 | 42.9 |
| Capital Equipment | 3.6 | | 3.0 | | 4.6 | | 4.5 | | 4.5 | | 5.5 | | 5.5 | |
| Total Program | 40.3 | | 30.6 | | 37.8 | | 41.3 | | 44.6 | | 48.4 | | 48.4 | |
| Proposed Construction | 0.0 | | 0.0 | | 0.0 | | 5.0 | | 15.0 | | 50.0 | | 100.0 | |
| Direct Personnel | 214.9 | | 185.4 | | 176.3 | | 178.0 | | 191.0 | | 207.0 | | 207.0 | |
| **AG25 High Temperature Reactor Technology** | | | | | | | | | | | | | | |
| Internal Operating | | 4.9 | | 4.6 | | 5.0 | | 5.6 | | 5.8 | | 6.7 | | 7.5 |
| Procurement | | 0.3 | | 0.4 | | 0.5 | | 0.5 | | 0.7 | | 1.3 | | 1.5 |
| Total Operating | 5.3 | 5.3 | 5.0 | 5.0 | 5.5 | 5.5 | 6.0 | 6.0 | 6.5 | 6.5 | 8.0 | 8.0 | 9.0 | 9.0 |
| Capital Equipment | 0.9 | | 1.2 | | 2.0 | | 2.0 | | 2.0 | | 1.5 | | 1.5 | |
| Total Activity | 6.2 | | 6.2 | | 7.5 | | 8.0 | | 8.5 | | 9.5 | | 10.5 | |
| Proposed Construction | 0.0 | | 0.0 | | 0.0 | | 6.5 | | 2.7 | | 0.3 | | 0.0 | |
| Direct Personnel | 40.8 | | 37.0 | | 37.0 | | 40.0 | | 42.0 | | 45.0 | | 50.0 | |

Table A.2 (continued)

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **AG30 Three Mile Island Activities** | | | | | | | | | | | | | | |
| Internal Operating | | 0.2 | | 0.3 | | 0.3 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.3 | 0.2 | 0.3 | 0.3 | 0.3 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 2.0 | | 3.0 | | 3.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| **AG36 Light Water Reactor Systems** | | | | | | | | | | | | | | |
| Internal Operating | | 0.2 | | 1.1 | | 0.6 | | 0.6 | | 0.6 | | 0.6 | | 0.6 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.2 | 0.2 | 1.1 | 1.1 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| Direct Personnel | 0.3 | | 2.0 | | 1.5 | | 1.5 | | 1.5 | | 1.5 | | 1.5 | |
| **AG40 Thermal Reactor Fuel Cycle** | | | | | | | | | | | | | | |
| Internal Operating | | 0.4 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 3.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 3.0 | 3.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 3.5 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |

**Table A.2 (continued)**

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **AG CONVENTIONAL REACTOR SYSTEMS** | | | | | | | | | | | | | | |
| Internal Operating | | 5.8 | | 6.0 | | 6.0 | | 6.2 | | 6.4 | | 7.3 | | 8.1 |
| Procurement | | 3.3 | | 0.4 | | 0.5 | | 0.5 | | 0.7 | | 1.3 | | 1.5 |
| Total Operating | 8.8 | 9.1 | 6.4 | 6.4 | 6.4 | 6.4 | 6.6 | 6.6 | 7.1 | 7.1 | 8.6 | 8.6 | 9.6 | 9.6 |
| Capital Equipment | 0.9 | | 1.2 | | 2.0 | | 2.0 | | 2.0 | | 1.5 | | 1.5 | |
| Total Program | 9.7 | | 7.6 | | 8.4 | | 8.6 | | 9.1 | | 10.1 | | 11.1 | |
| Proposed Construction | 0.0 | | 0.0 | | 0.0 | | 6.5 | | 2.7 | | 0.3 | | 0.0 | |
| Direct Personnel | 46.6 | | 42.0 | | 41.5 | | 41.5 | | 43.5 | | 46.5 | | 51.5 | |
| **AH10 Remedial Actions** | | | | | | | | | | | | | | |
| Internal Operating | | 0.7 | | 1.0 | | 1.1 | | 1.1 | | 1.1 | | 0.9 | | 0.2 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.2 | | 0.9 |
| Total Operating | 0.4 | 0.7 | 1.0 | 1.0 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 |
| Direct Personnel | 5.2 | | 4.6 | | 4.7 | | 3.3 | | 4.1 | | 2.5 | | 3.4 | |
| **AH REMEDIAL ACTION PROGRAMS** | | | | | | | | | | | | | | |
| Internal Operating | | 0.7 | | 1.0 | | 1.1 | | 1.1 | | 1.1 | | 0.9 | | 0.2 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.2 | | 0.9 |
| Total Operating | 0.4 | 0.7 | 1.0 | 1.0 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 |
| Direct Personnel | 5.2 | | 4.6 | | 4.7 | | 3.3 | | 4.1 | | 2.5 | | 3.4 | |

Table A.2 (continued)

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **AP05 Commerical Waste Management Program** | | | | | | | | | | | | | | |
| Internal Operating | | 1.9 | | 1.6 | | 1.4 | | 1.2 | | 1.4 | | 1.6 | | 1.6 |
| Procurement | | 0.1 | | 0.1 | | 0.3 | | 0.5 | | 0.3 | | 0.1 | | 0.1 |
| Total Operating | 1.9 | 2.0 | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 |
| Capital Equipment | 0.1 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| Total Activity | 2.0 | | 1.7 | | 1.7 | | 1.7 | | 1.7 | | 1.7 | | 1.7 | |
| Direct Personnel | 16.8 | | 13.0 | | 13.0 | | 13.0 | | 13.0 | | 13.0 | | 13.0 | |
| **AP COMMERCIAL NUCLEAR WASTE MANAGEMENT** | | | | | | | | | | | | | | |
| Internal Operating | | 1.9 | | 1.6 | | 1.4 | | 1.2 | | 1.4 | | 1.6 | | 1.6 |
| Procurement | | 0.1 | | 0.1 | | 0.3 | | 0.5 | | 0.3 | | 0.1 | | 0.1 |
| Total Operating | 1.9 | 2.0 | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 |
| Capital Equipment | 0.1 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| Total Program | 2.0 | | 1.7 | | 1.7 | | 1.7 | | 1.7 | | 1.7 | | 1.7 | |
| Direct Personnel | 16.8 | | 13.0 | | 13.0 | | 13.0 | | 13.0 | | 13.0 | | 13.0 | |
| **AW01 Advanced Isotope Separation Techn** | | | | | | | | | | | | | | |
| Internal Operating | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.4 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.4 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |

Table A.2 (continued)

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **AW ADVANCED ISOTOPE SEPARATION** | | | | | | | | | | | | | | |
| Internal Operating | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.4 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.4 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| **CD10 Uranium Enrichment Activities** | | | | | | | | | | | | | | |
| Internal Operating | | 0.2 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.2 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 0.8 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| **CD20 Uranium Resource Assessment** | | | | | | | | | | | | | | |
| Internal Operating | | 0.3 | | 0.2 | | 0.2 | | 0.2 | | 0.1 | | 0.1 | | 0.0 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.3 | 0.3 | 0.2 | 0.2 | 0.3 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 |
| Direct Personnel | 0.5 | | 1.0 | | 1.3 | | 0.8 | | 0.6 | | 0.4 | | 0.0 | |

Table A.2 (continued)

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **CD URANIUM RESOURCES & ENRICHMENT** | | | | | | | | | | | | | | |
| Internal Operating | | 0.5 | | 0.2 | | 0.2 | | 0.2 | | 0.1 | | 0.1 | | 0.0 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.5 | 0.5 | 0.2 | 0.2 | 0.3 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 |
| Direct Personnel | 1.3 | | 1.0 | | 1.3 | | 0.8 | | 0.6 | | 0.4 | | 0.0 | |
| **Assistant Secretary for Nuclear Energy** | | | | | | | | | | | | | | |
| Internal Operating | | 36.3 | | 37.9 | | 40.0 | | 41.0 | | 43.5 | | 47.9 | | 50.4 |
| Procurement | | 9.7 | | 5.2 | | 6.5 | | 8.6 | | 9.5 | | 10.6 | | 9.0 |
| Total Operating | 51.3 | 46.0 | 42.4 | 43.1 | 47.2 | 46.5 | 50.5 | 49.6 | 54.3 | 53.0 | 58.5 | 58.5 | 59.4 | 59.4 |
| Capital Equipment | 4.7 | | 4.5 | | 6.6 | | 6.6 | | 6.6 | | 7.1 | | 7.1 | |
| Total Asst Secretary | 56.0 | | 46.9 | | 53.9 | | 57.1 | | 60.8 | | 65.6 | | 66.5 | |
| Proposed Construction | 0.0 | | 0.0 | | 0.0 | | 11.5 | | 17.7 | | 50.3 | | 100.0 | |
| Direct Personnel | 300.8 | | 276.0 | | 256.8 | | 255.6 | | 271.2 | | 288.4 | | 293.9 | |
| **AS for Conservation and Renewable Energy** | | | | | | | | | | | | | | |
| **AK05 Power Delivery** | | | | | | | | | | | | | | |
| Internal Operating | | 1.3 | | 1.4 | | 1.4 | | 1.4 | | 1.4 | | 1.4 | | 1.4 |
| Procurement | | 1.6 | | 1.0 | | 0.4 | | 0.1 | | 0.1 | | 0.1 | | 0.1 |
| Total Operating | 2.2 | 2.9 | 1.4 | 2.4 | 1.8 | 1.8 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| Capital Equipment | 0.1 | | 0.1 | | 0.2 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | |
| Total Activity | 2.3 | | 1.6 | | 2.0 | | 1.6 | | 1.6 | | 1.6 | | 1.6 | |
| Direct Personnel | 9.0 | | 8.6 | | 8.0 | | 8.0 | | 8.0 | | 8.0 | | 8.0 | |

**Table A.2 (continued)**

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **AK10 Systems Architecture & Integration** | | | | | | | | | | | | | | |
| Internal Operating | | 0.8 | | 1.2 | | 1.1 | | 1.0 | | 1.0 | | 1.0 | | 1.0 |
| Procurement | | 2.4 | | 5.6 | | 2.3 | | 0.2 | | 0.2 | | 0.2 | | 0.2 |
| Total Operating | 1.5 | 3.3 | 1.2 | 6.8 | 1.3 | 3.4 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 |
| Direct Personnel | 6.2 | | 8.0 | | 7.0 | | 6.0 | | 6.0 | | 6.0 | | 6.0 | |
| **AK ELECTRIC ENERGY SYSTEMS** | | | | | | | | | | | | | | |
| Internal Operating | | 2.1 | | 2.5 | | 2.5 | | 2.3 | | 2.3 | | 2.3 | | 2.3 |
| Procurement | | 4.1 | | 6.6 | | 2.7 | | 0.4 | | 0.4 | | 0.4 | | 0.4 |
| Total Operating | 3.8 | 6.2 | 2.7 | 9.2 | 3.1 | 5.2 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 |
| Capital Equipment | 0.1 | | 0.2 | | 0.2 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | |
| Total Program | 3.9 | | 2.8 | | 3.3 | | 2.8 | | 2.8 | | 2.8 | | 2.8 | |
| Direct Personnel | 15.2 | | 16.6 | | 15.0 | | 14.0 | | 14.0 | | 14.0 | | 14.0 | |
| **AL05 Battery Storage** | | | | | | | | | | | | | | |
| Internal Operating | | 0.1 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 0.4 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |

Table A.2 (continued)

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **AL10 Thermal and Mechanical Storage** | | | | | | | | | | | | | | |
| Internal Operating | | 1.6 | | 1.0 | | 0.9 | | 0.5 | | 0.5 | | 0.5 | | 0.5 |
| Procurement | | 2.1 | | 0.3 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 |
| Total Operating | 1.5 | 3.6 | 0.1 | 1.3 | 0.9 | 1.0 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| Capital Equipment | 0.1 | | 0.0 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | |
| Total Activity | 1.6 | | 0.1 | | 1.0 | | 0.7 | | 0.7 | | 0.7 | | 0.7 | |
| Direct Personnel | 10.0 | | 6.1 | | 5.2 | | 3.0 | | 3.0 | | 3.0 | | 3.0 | |
| **AL ENERGY STORAGE SYSTEMS** | | | | | | | | | | | | | | |
| Internal Operating | | 1.6 | | 1.0 | | 0.9 | | 0.5 | | 0.5 | | 0.5 | | 0.5 |
| Procurement | | 2.1 | | 0.3 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 |
| Total Operating | 1.5 | 3.7 | 0.1 | 1.3 | 0.9 | 1.0 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| Capital Equipment | 0.1 | | 0.0 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | |
| Total Program | 1.6 | | 0.1 | | 1.0 | | 0.7 | | 0.7 | | 0.7 | | 0.7 | |
| Direct Personnel | 10.4 | | 6.1 | | 5.2 | | 3.0 | | 3.0 | | 3.0 | | 3.0 | |
| **AM05 Geopressured Resources Development** | | | | | | | | | | | | | | |
| Internal Operating | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.0 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Direct Personnel | 0.6 | | 0.6 | | 0.6 | | 0.6 | | 0.6 | | 0.6 | | 0.6 | |

Table A.2 (continued)

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **AM10 Geothermal Technology Development** | | | | | | | | | | | | | | |
| Internal Operating | | 0.3 | | 0.4 | | 0.4 | | 0.2 | | 0.2 | | 0.2 | | 0.2 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.2 | 0.3 | 0.4 | 0.4 | 0.4 | 0.4 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Direct Personnel | 2.3 | | 2.7 | | 3.0 | | 1.4 | | 1.4 | | 1.4 | | 1.4 | |
| **AM15 Hydrothermal Industrialization** | | | | | | | | | | | | | | |
| Internal Operating | | 0.1 | | 0.4 | | 0.4 | | 0.2 | | 0.2 | | 0.2 | | 0.2 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.0 | 0.1 | 0.4 | 0.4 | 0.3 | 0.4 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Direct Personnel | 0.6 | | 3.0 | | 2.5 | | 1.4 | | 1.4 | | 1.4 | | 1.4 | |
| **AM GEOTHERMAL** | | | | | | | | | | | | | | |
| Internal Operating | | 0.5 | | 0.9 | | 0.9 | | 0.5 | | 0.5 | | 0.5 | | 0.5 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.2 | 0.5 | 0.9 | 0.9 | 0.8 | 0.9 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| Direct Personnel | 3.5 | | 6.3 | | 6.1 | | 3.4 | | 3.4 | | 3.4 | | 3.4 | |

Table A.2 (continued)

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **CE10 Small Scale Hydropower** | | | | | | | | | | | | | | |
| Internal Operating | | 0.4 | | 0.1 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.4 | 0.4 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 3.6 | | 1.5 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| **CE HYDROPOWER** | | | | | | | | | | | | | | |
| Internal Operating | | 0.4 | | 0.1 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.4 | 0.4 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 3.6 | | 1.5 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| **EB01 Solar Applications for Buildings** | | | | | | | | | | | | | | |
| Internal Operating | | 0.2 | | 0.1 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.0 | | 0.1 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.2 | 0.2 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 2.0 | | 0.8 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |

**Table A.2 (continued)**

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **EB02 Solar Applications for Industry** | | | | | | | | | | | | | | |
| Internal Operating | | 1.1 | | 0.5 | | 0.5 | | 0.6 | | 0.6 | | 0.6 | | 0.6 |
| Procurement | | 3.0 | | 2.5 | | 1.5 | | 1.4 | | 1.4 | | 1.4 | | 1.4 |
| Total Operating | 4.3 | 4.1 | 0.5 | 3.0 | 1.9 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 |
| Capital Equipment | 0.2 | | 0.0 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | |
| Total Activity | 4.4 | | 0.5 | | 2.0 | | 2.1 | | 2.1 | | 2.1 | | 2.1 | |
| Direct Personnel | 9.7 | | 4.0 | | 4.0 | | 4.0 | | 4.0 | | 4.0 | | 4.0 | |
| **EB03 Solar Applications for Power** | | | | | | | | | | | | | | |
| Internal Operating | | 0.5 | | 0.1 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.3 | 0.5 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 4.0 | | 0.5 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| **EB04 Other Solar Programs** | | | | | | | | | | | | | | |
| Internal Operating | | 0.1 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 1.3 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |

Table A.2 (continued)

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **EB11 Alcohol Financial Assistance** | | | | | | | | | | | | | | |
| Internal Operating | | 0.6 | | 0.2 | | 0.2 | | 0.2 | | 0.2 | | 0.2 | | 0.2 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.0 | 0.6 | 0.3 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Direct Personnel | 5.7 | | 1.7 | | 1.6 | | 1.6 | | 1.6 | | 1.6 | | 1.6 | |
| **EB SOLAR ENERGY** | | | | | | | | | | | | | | |
| Internal Operating | | 2.6 | | 0.9 | | 0.7 | | 0.8 | | 0.8 | | 0.8 | | 0.8 |
| Procurement | | 3.0 | | 2.6 | | 1.5 | | 1.4 | | 1.4 | | 1.4 | | 1.4 |
| Total Operating | 5.0 | 5.6 | 0.8 | 3.4 | 2.1 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 |
| Capital Equipment | 0.2 | | 0.0 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | |
| Total Program | 5.1 | | 0.8 | | 2.2 | | 2.3 | | 2.3 | | 2.3 | | 2.3 | |
| Direct Personnel | 22.7 | | 7.0 | | 5.6 | | 5.6 | | 5.6 | | 5.6 | | 5.6 | |
| **EC01 Buildings Systems** | | | | | | | | | | | | | | |
| Internal Operating | | 0.8 | | 1.4 | | 1.8 | | 1.8 | | 1.8 | | 1.8 | | 1.8 |
| Procurement | | 1.1 | | 2.8 | | 1.0 | | 1.1 | | 1.1 | | 1.1 | | 1.1 |
| Total Operating | 3.6 | 1.9 | 2.9 | 4.2 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 |
| Capital Equipment | 0.0 | | 0.5 | | 0.6 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| Total Activity | 3.6 | | 3.3 | | 3.4 | | 2.8 | | 2.8 | | 2.8 | | 2.8 | |
| Direct Personnel | 4.4 | | 7.5 | | 8.7 | | 8.5 | | 8.5 | | 8.5 | | 8.5 | |

**Table A.2 (continued)**

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **EC03 Community Systems** | | | | | | | | | | | | | | |
| Internal Operating | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| 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 |
| Direct Personnel | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| **EC04 Urban Waste** | | | | | | | | | | | | | | |
| Internal Operating | | 0.3 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.1 | | 0.1 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.5 | 0.4 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 3.6 | | 0.5 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| **EC05 Technology and Consumer Products** | | | | | | | | | | | | | | |
| Internal Operating | | 2.9 | | 2.6 | | 2.8 | | 2.8 | | 2.8 | | 2.8 | | 2.8 |
| Procurement | | 6.7 | | 5.1 | | 5.2 | | 4.2 | | 4.2 | | 4.2 | | 4.2 |
| Total Operating | 6.7 | 9.6 | 7.0 | 7.7 | 7.0 | 8.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 |
| Capital Equipment | 0.0 | | 0.0 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | |
| Total Activity | 6.7 | | 7.0 | | 7.1 | | 7.1 | | 7.1 | | 7.1 | | 7.1 | |
| Direct Personnel | 24.6 | | 20.0 | | 20.0 | | 20.0 | | 20.0 | | 20.0 | | 20.0 | |

Table A.2 (continued)

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **EC06 Analysis and Technology Transfer** | | | | | | | | | | | | | | |
| Internal Operating | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.3 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 0.3 | | 0.3 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| **EC07 Residential Conservation Service** | | | | | | | | | | | | | | |
| Internal Operating | | 1.4 | | 1.2 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.3 | | 0.4 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 2.2 | 1.7 | 0.0 | 1.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 12.0 | | 9.7 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| **EC BUILDINGS AND COMMUNITY SYSTEMS** | | | | | | | | | | | | | | |
| Internal Operating | | 5.5 | | 5.3 | | 4.6 | | 4.6 | | 4.6 | | 4.6 | | 4.6 |
| Procurement | | 8.5 | | 8.3 | | 6.2 | | 5.3 | | 5.3 | | 5.3 | | 5.3 |
| Total Operating | 13.0 | 14.0 | 9.9 | 13.6 | 9.8 | 10.8 | 9.8 | 9.8 | 9.8 | 9.8 | 9.8 | 9.8 | 9.8 | 9.8 |
| Capital Equipment | 0.1 | | 0.5 | | 0.7 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | |
| Total Program | 13.0 | | 10.4 | | 10.5 | | 9.9 | | 9.9 | | 9.9 | | 9.9 | |
| Direct Personnel | 44.9 | | 38.0 | | 28.7 | | 28.5 | | 28.5 | | 28.5 | | 28.5 | |

**Table A.2 (continued)**

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **ED01 Waste Energy Reduction** | | | | | | | | | | | | | | |
| Internal Operating | | 0.6 | | 1.5 | | 0.7 | | 0.5 | | 0.5 | | 0.5 | | 0.5 |
| Procurement | | 0.2 | | 0.6 | | 0.2 | | 0.2 | | 0.2 | | 0.2 | | 0.2 |
| Total Operating | 1.8 | 0.8 | 1.3 | 2.0 | 0.8 | 1.0 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| Direct Personnel | 4.5 | | 10.5 | | 4.8 | | 3.0 | | 3.0 | | 3.0 | | 3.0 | |
| **ED02 Industrial Process Efficiency** | | | | | | | | | | | | | | |
| Internal Operating | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| 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 |
| Direct Personnel | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| **ED03 Industrial Cogeneration** | | | | | | | | | | | | | | |
| Internal Operating | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.1 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |

Table A.2 (continued)

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **ED INDUSTRIAL** | | | | | | | | | | | | | | |
| Internal Operating | | 0.6 | | 1.5 | | 0.7 | | 0.5 | | 0.5 | | 0.5 | | 0.5 |
| Procurement | | 0.3 | | 0.6 | | 0.2 | | 0.2 | | 0.2 | | 0.2 | | 0.2 |
| Total Operating | 1.8 | 0.9 | 1.3 | 2.0 | 0.8 | 1.0 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| Direct Personnel | 4.5 | | 10.5 | | 4.8 | | 3.0 | | 3.0 | | 3.0 | | 3.0 | |
| **EE01 Vehicle Propulsion Research & Dev** | | | | | | | | | | | | | | |
| Internal Operating | | 0.2 | | 0.7 | | 0.7 | | 0.7 | | 0.7 | | 0.7 | | 0.7 |
| Procurement | | 0.0 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 |
| Total Operating | 0.6 | 0.2 | 0.7 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 |
| Capital Equipment | 0.0 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | |
| Total Activity | 0.6 | | 0.7 | | 0.8 | | 0.8 | | 0.8 | | 0.8 | | 0.8 | |
| Direct Personnel | 2.2 | | 6.1 | | 5.1 | | 5.5 | | 5.5 | | 5.5 | | 5.5 | |
| **EE03 Vehicle Systems** | | | | | | | | | | | | | | |
| Internal Operating | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| 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 |
| Direct Personnel | 0.1 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |

**Table A.2 (continued)**

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **EE05 Transportation Utilization Program** | | | | | | | | | | | | | | |
| Internal Operating | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 0.5 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| **EE TRANSPORTATION** | | | | | | | | | | | | | | |
| Internal Operating | | 0.3 | | 0.7 | | 0.7 | | 0.7 | | 0.7 | | 0.7 | | 0.7 |
| Procurement | | 0.0 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 |
| Total Operating | 0.6 | 0.3 | 0.7 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 |
| Capital Equipment | 0.0 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | |
| Total Program | 0.6 | | 0.7 | | 0.8 | | 0.8 | | 0.8 | | 0.8 | | 0.8 | |
| Direct Personnel | 2.8 | | 6.1 | | 5.1 | | 5.5 | | 5.5 | | 5.5 | | 5.5 | |
| **EF01 Schools and Hospitals** | | | | | | | | | | | | | | |
| Internal Operating | | 0.1 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 0.8 | | 0.3 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |

Table A.2 (continued)

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **EF04 Energy Policy & Conservation Grants** | | | | | | | | | | | | | | |
| Internal Operating | | 0.0 | | 0.2 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.4 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.2 | 0.4 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 0.0 | | 2.4 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| **EF05 Energy Conserv. Production Grants** | | | | | | | | | | | | | | |
| Internal Operating | | 0.2 | | 0.1 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.1 | 0.2 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 2.7 | | 0.2 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| **EF STATE/LOCAL PROGRAMS** | | | | | | | | | | | | | | |
| Internal Operating | | 0.4 | | 0.3 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.4 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.4 | 0.8 | 0.0 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 4.1 | | 2.9 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |

**Table A.2 (continued)**

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **EG05 Energy Conversion Technology** | | | | | | | | | | | | | | |
| Internal Operating | | 0.4 | | 0.6 | | 0.6 | | 0.6 | | 0.6 | | 0.6 | | 0.6 |
| Procurement | | 0.3 | | 0.5 | | 0.5 | | 0.5 | | 0.5 | | 0.5 | | 0.5 |
| Total Operating | 0.8 | 0.8 | 1.4 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 |
| Capital Equipment | 0.1 | | 0.0 | | 0.1 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| Total Activity | 0.9 | | 1.4 | | 1.2 | | 1.1 | | 1.1 | | 1.1 | | 1.1 | |
| Direct Personnel | 3.8 | | 4.7 | | 4.1 | | 4.0 | | 4.0 | | 4.0 | | 4.0 | |
| **EG06 Inventors Program** | | | | | | | | | | | | | | |
| Internal Operating | | 0.1 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.1 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.2 | 0.2 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 0.8 | | 0.1 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| **EG MULTI-SECTOR** | | | | | | | | | | | | | | |
| Internal Operating | | 0.5 | | 0.6 | | 0.6 | | 0.6 | | 0.6 | | 0.6 | | 0.6 |
| Procurement | | 0.4 | | 0.5 | | 0.5 | | 0.5 | | 0.5 | | 0.5 | | 0.5 |
| Total Operating | 1.0 | 1.0 | 1.4 | 1.2 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 |
| Capital Equipment | 0.1 | | 0.0 | | 0.1 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| Total Program | 1.2 | | 1.4 | | 1.2 | | 1.1 | | 1.1 | | 1.1 | | 1.1 | |
| Direct Personnel | 4.6 | | 4.8 | | 4.1 | | 4.0 | | 4.0 | | 4.0 | | 4.0 | |

Table A.2 (continued)

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **AS for Conservation and Renewable Energy** | | | | | | | | | | | | | | |
| Internal Operating | | 14.3 | | 13.8 | | 11.6 | | 10.4 | | 10.4 | | 10.4 | | 10.4 |
| Procurement | | 18.8 | | 19.0 | | 11.3 | | 7.9 | | 7.9 | | 7.9 | | 7.9 |
| Total Operating | 27.6 | 33.1 | 17.8 | 32.9 | 19.3 | 22.9 | 18.2 | 18.3 | 18.3 | 18.3 | 18.3 | 18.3 | 18.3 | 18.3 |
| Capital Equipment | 0.6 | | 0.8 | | 1.2 | | 0.4 | | 0.4 | | 0.4 | | 0.4 | |
| Total Asst Secretary | 28.1 | | 18.5 | | 20.5 | | 18.6 | | 18.7 | | 18.7 | | 18.7 | |
| Direct Personnel | 115.7 | | 99.8 | | 74.6 | | 67.0 | | 67.0 | | 67.0 | | 67.0 | |
| **Office of Policy, Planning & Analysis** | | | | | | | | | | | | | | |
| **PE01 Policy, Planning and Analysis** | | | | | | | | | | | | | | |
| Internal Operating | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 |
| Procurement | | 0.3 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.2 | 0.3 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Direct Personnel | 0.3 | | 0.4 | | 0.4 | | 0.4 | | 0.4 | | 0.4 | | 0.4 | |
| **PE POLICY ANALYSIS & SYSTEMS STUDIES** | | | | | | | | | | | | | | |
| Internal Operating | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 |
| Procurement | | 0.3 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.2 | 0.3 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Direct Personnel | 0.3 | | 0.4 | | 0.4 | | 0.4 | | 0.4 | | 0.4 | | 0.4 | |

**Table A.2 (continued)**

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **Office of Policy, Planning & Analysis** | | | | | | | | | | | | | | |
| Internal Operating | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 |
| Procurement | | 0.3 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.2 | 0.3 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Direct Personnel | 0.3 | | 0.4 | | 0.4 | | 0.4 | | 0.4 | | 0.4 | | 0.4 | |
| **Office of Energy Research** | | | | | | | | | | | | | | |
| **AT05 Applied Plasma Physics** | | | | | | | | | | | | | | |
| Internal Operating | | 4.1 | | 4.7 | | 5.1 | | 5.1 | | 5.1 | | 5.1 | | 5.1 |
| Procurement | | 0.3 | | 0.5 | | 0.4 | | 0.4 | | 0.4 | | 0.4 | | 0.4 |
| Total Operating | 4.4 | 4.4 | 5.4 | 5.2 | 5.7 | 5.5 | 5.5 | 5.5 | 5.5 | 5.5 | 5.5 | 5.5 | 5.5 | 5.5 |
| Capital Equipment | 0.2 | | 0.3 | | 0.3 | | 0.3 | | 0.3 | | 0.3 | | 0.3 | |
| Total Activity | 4.6 | | 5.7 | | 6.0 | | 5.8 | | 5.8 | | 5.8 | | 5.8 | |
| Direct Personnel | 28.0 | | 33.0 | | 33.0 | | 33.0 | | 33.0 | | 33.0 | | 33.0 | |
| **AT10 Confinement Systems** | | | | | | | | | | | | | | |
| Internal Operating | | 15.2 | | 19.5 | | 20.7 | | 20.7 | | 20.7 | | 20.7 | | 20.7 |
| Procurement | | 5.4 | | 6.2 | | 12.3 | | 12.3 | | 12.3 | | 12.3 | | 12.3 |
| Total Operating | 20.9 | 20.6 | 27.3 | 25.7 | 39.4 | 33.0 | 33.0 | 33.0 | 33.0 | 33.0 | 33.0 | 33.0 | 33.0 | 33.0 |
| Capital Equipment | 3.8 | | 3.8 | | 3.8 | | 3.8 | | 3.8 | | 3.8 | | 3.8 | |
| Construction | 13.4 | | 0.0 | | 25.0 | | 45.0 | | 27.0 | | 4.2 | | 0.0 | |
| Total Activity | 38.1 | | 31.1 | | 68.1 | | 81.7 | | 63.7 | | 40.9 | | 36.7 | |
| Direct Personnel | 72.5 | | 74.6 | | 76.9 | | 76.9 | | 76.9 | | 76.9 | | 76.9 | |

**Table A.2 (continued)**

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **AT15 Development and Technology** | | | | | | | | | | | | | | |
| Internal Operating | | 13.3 | | 21.4 | | 23.1 | | 23.1 | | 23.1 | | 23.1 | | 23.1 |
| Procurement | | 13.8 | | 10.1 | | 11.3 | | 11.3 | | 11.3 | | 11.3 | | 11.3 |
| Total Operating | 26.7 | 27.1 | 31.5 | 31.5 | 35.5 | 34.4 | 34.4 | 34.4 | 34.4 | 34.4 | 34.4 | 34.4 | 34.4 | 34.4 |
| Capital Equipment | 5.5 | | 8.0 | | 3.0 | | 3.0 | | 3.0 | | 3.0 | | 3.0 | |
| Construction | 6.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| Total Activity | 38.1 | | 39.5 | | 38.5 | | 37.4 | | 37.4 | | 37.4 | | 37.4 | |
| Direct Personnel | 73.0 | | 92.9 | | 91.2 | | 91.2 | | 91.2 | | 91.2 | | 91.2 | |
| **AT25 Center for Magnetic Fusion Energy** | | | | | | | | | | | | | | |
| Internal Operating | | 1.7 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 2.1 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 3.8 | 3.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 3.6 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| **AT FUSION ENERGY R&D** | | | | | | | | | | | | | | |
| Internal Operating | | 34.3 | | 45.6 | | 48.9 | | 48.9 | | 48.9 | | 48.9 | | 48.9 |
| Procurement | | 21.6 | | 16.7 | | 24.0 | | 24.0 | | 24.0 | | 24.0 | | 24.0 |
| Total Operating | 55.8 | 55.9 | 64.2 | 62.4 | 80.5 | 72.9 | 72.9 | 72.9 | 72.9 | 72.9 | 72.9 | 72.9 | 72.9 | 72.9 |
| Capital Equipment | 9.5 | | 12.1 | | 7.1 | | 7.1 | | 7.1 | | 7.1 | | 7.1 | |
| Construction | 19.4 | | 0.0 | | 25.0 | | 45.0 | | 27.0 | | 4.2 | | 0.0 | |
| Total Program | 84.7 | | 76.2 | | 112.6 | | 124.9 | | 106.9 | | 84.1 | | 79.9 | |
| Direct Personnel | 177.1 | | 200.5 | | 201.1 | | 201.1 | | 201.1 | | 201.1 | | 201.1 | |

**Table A.2 (continued)**

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **HA02 Biological & Environmental Research** | | | | | | | | | | | | | | |
| Internal Operating | | 18.8 | | 16.7 | | 18.2 | | 19.7 | | 19.7 | | 19.7 | | 19.7 |
| Procurement | | 1.6 | | 1.3 | | 1.8 | | 1.8 | | 1.8 | | 1.8 | | 1.8 |
| Total Operating | 20.2 | 20.4 | 16.4 | 18.0 | 20.5 | 20.0 | 21.5 | 21.5 | 21.5 | 21.5 | 21.5 | 21.5 | 21.5 | 21.5 |
| Capital Equipment | 1.6 | | 1.5 | | 1.6 | | 1.7 | | 1.8 | | 1.9 | | 2.0 | |
| Construction | 1.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| Total Activity | 22.8 | | 17.9 | | 22.1 | | 23.2 | | 23.3 | | 23.4 | | 23.5 | |
| Proposed Construction | 0.0 | | 1.6 | | 0.0 | | 6.0 | | 16.3 | | 27.7 | | 0.0 | |
| Direct Personnel | 163.0 | | 130.0 | | 140.0 | | 145.0 | | 150.0 | | 150.0 | | 150.0 | |
| **HA ENVIRONMENTAL RES & DEVELOPMENT** | | | | | | | | | | | | | | |
| Internal Operating | | 23.3 | | 19.7 | | 21.4 | | 22.9 | | 22.9 | | 22.9 | | 22.9 |
| Procurement | | 3.3 | | 2.4 | | 2.7 | | 2.7 | | 2.7 | | 2.7 | | 2.7 |
| Total Operating | 26.1 | 26.6 | 20.6 | 22.1 | 24.7 | 24.1 | 25.6 | 25.6 | 25.6 | 25.6 | 25.6 | 25.6 | 25.6 | 25.6 |
| Capital Equipment | 1.6 | | 1.8 | | 1.8 | | 2.0 | | 2.1 | | 2.2 | | 2.3 | |
| Construction | 1.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| Total Program | 28.7 | | 22.4 | | 26.5 | | 27.6 | | 27.7 | | 27.8 | | 27.9 | |
| Proposed Construction | 0.0 | | 1.6 | | 0.0 | | 6.0 | | 16.3 | | 27.7 | | 0.0 | |
| Direct Personnel | 200.2 | | 155.0 | | 161.0 | | 166.0 | | 171.0 | | 171.0 | | 171.0 | |
| **HB01 General Life Sciences** | | | | | | | | | | | | | | |
| Internal Operating | | 6.0 | | 4.9 | | 5.6 | | 6.6 | | 6.6 | | 6.6 | | 6.6 |
| Procurement | | 0.4 | | 0.3 | | 0.4 | | 0.4 | | 0.4 | | 0.4 | | 0.4 |
| Total Operating | 6.6 | 6.4 | 5.1 | 5.2 | 6.5 | 6.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 |
| Capital Equipment | 0.2 | | 0.3 | | 0.3 | | 0.3 | | 0.3 | | 0.3 | | 0.3 | |
| Total Activity | 6.8 | | 5.4 | | 6.8 | | 7.3 | | 7.3 | | 7.3 | | 7.3 | |
| Direct Personnel | 54.0 | | 40.9 | | 45.0 | | 50.0 | | 50.0 | | 50.0 | | 50.0 | |

Table A.2 (continued)

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **HB02 Nuclear Medicine Applications** | | | | | | | | | | | | | | |
| Internal Operating | | 1.3 | | 1.5 | | 1.6 | | 1.6 | | 1.6 | | 1.6 | | 1.6 |
| Procurement | | 0.1 | | 0.0 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 |
| Total Operating | 1.4 | 1.4 | 1.5 | 1.5 | 1.7 | 1.6 | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 |
| Capital Equipment | 0.1 | | 0.2 | | 0.1 | | 0.2 | | 0.2 | | 0.2 | | 0.2 | |
| Total Activity | 1.4 | | 1.7 | | 1.8 | | 1.9 | | 1.9 | | 1.9 | | 1.9 | |
| Direct Personnel | 9.5 | | 9.5 | | 10.0 | | 11.0 | | 11.0 | | 11.0 | | 11.0 | |
| **HB LIFE SCIENCES RES & NUCLEAR MED** | | | | | | | | | | | | | | |
| Internal Operating | | 7.3 | | 6.3 | | 7.2 | | 8.2 | | 8.2 | | 8.2 | | 8.2 |
| Procurement | | 0.5 | | 0.4 | | 0.4 | | 0.5 | | 0.5 | | 0.5 | | 0.5 |
| Total Operating | 7.9 | 7.8 | 6.6 | 6.7 | 8.2 | 7.6 | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 |
| Capital Equipment | 0.3 | | 0.4 | | 0.4 | | 0.5 | | 0.5 | | 0.5 | | 0.5 | |
| Total Program | 8.2 | | 7.1 | | 8.6 | | 9.2 | | 9.2 | | 9.2 | | 9.2 | |
| Direct Personnel | 63.5 | | 50.4 | | 55.0 | | 61.0 | | 61.0 | | 61.0 | | 61.0 | |
| **KA01 Physics Research** | | | | | | | | | | | | | | |
| Internal Operating | | 0.6 | | 0.6 | | 0.7 | | 0.7 | | 0.7 | | 0.7 | | 0.7 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.6 | 0.6 | 0.6 | 0.6 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 |
| Capital Equipment | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | |
| Total Activity | 0.6 | | 0.7 | | 0.8 | | 0.8 | | 0.8 | | 0.8 | | 0.8 | |
| Direct Personnel | 5.2 | | 5.2 | | 5.2 | | 5.2 | | 5.2 | | 5.2 | | 5.2 | |

**Table A.2 (continued)**

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **KA HIGH ENERGY PHYSICS** | | | | | | | | | | | | | | |
| Internal Operating | | 0.6 | | 0.6 | | 0.7 | | 0.7 | | 0.7 | | 0.7 | | 0.7 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.6 | 0.6 | 0.6 | 0.6 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 |
| Capital Equipment | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | |
| Total Program | 0.6 | | 0.7 | | 0.8 | | 0.8 | | 0.8 | | 0.8 | | 0.8 | |
| Direct Personnel | 5.2 | | 5.2 | | 5.2 | | 5.2 | | 5.2 | | 5.2 | | 5.2 | |
| **KB01 Medium Energy Physics** | | | | | | | | | | | | | | |
| Internal Operating | | 0.1 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 0.8 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| **KB02 Heavy Ion Physics** | | | | | | | | | | | | | | |
| Internal Operating | | 6.7 | | 6.8 | | 7.5 | | 7.5 | | 7.5 | | 7.5 | | 7.5 |
| Procurement | | 0.4 | | 0.4 | | 0.4 | | 0.4 | | 0.4 | | 0.4 | | 0.4 |
| Total Operating | 7.1 | 7.1 | 7.4 | 7.2 | 8.2 | 7.9 | 8.2 | 7.9 | 8.2 | 7.9 | 8.2 | 7.9 | 8.2 | 7.9 |
| Capital Equipment | 1.0 | | 0.9 | | 0.9 | | 0.9 | | 0.9 | | 0.9 | | 0.9 | |
| Construction | 0.5 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| Total Activity | 8.5 | | 8.3 | | 9.1 | | 9.1 | | 9.1 | | 9.1 | | 9.1 | |
| Proposed Construction | 0.0 | | 0.0 | | 28.5 | | 0.5 | | 0.0 | | 0.0 | | 0.0 | |
| Direct Personnel | 63.9 | | 62.1 | | 61.8 | | 61.8 | | 61.8 | | 61.8 | | 61.8 | |

Table A.2 (continued)

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **KB03 Nuclear Theory** | | | | | | | | | | | | | | |
| Internal Operating | | 0.6 | | 0.7 | | 0.7 | | 0.7 | | 0.7 | | 0.7 | | 0.7 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.6 | 0.6 | 0.7 | 0.7 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 |
| Direct Personnel | 6.0 | | 6.0 | | 6.5 | | 6.5 | | 6.5 | | 6.5 | | 6.5 | |
| **KB04 Low Energy Physics** | | | | | | | | | | | | | | |
| Internal Operating | | 1.0 | | 0.9 | | 1.0 | | 1.0 | | 1.0 | | 1.0 | | 1.0 |
| Procurement | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 |
| Total Operating | 0.9 | 1.1 | 1.0 | 1.0 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 |
| Capital Equipment | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | |
| Total Activity | 1.0 | | 1.1 | | 1.2 | | 1.2 | | 1.2 | | 1.2 | | 1.2 | |
| Direct Personnel | 7.5 | | 7.9 | | 7.9 | | 7.9 | | 7.9 | | 7.9 | | 7.9 | |
| **KB NUCLEAR PHYSICS** | | | | | | | | | | | | | | |
| Internal Operating | | 8.4 | | 8.4 | | 9.2 | | 9.2 | | 9.2 | | 9.2 | | 9.2 |
| Procurement | | 0.5 | | 0.5 | | 0.5 | | 0.5 | | 0.5 | | 0.5 | | 0.5 |
| Total Operating | 8.7 | 8.9 | 9.1 | 8.9 | 10.1 | 9.8 | 10.1 | 9.8 | 10.1 | 9.8 | 10.1 | 9.8 | 10.1 | 9.8 |
| Capital Equipment | 1.1 | | 1.0 | | 1.0 | | 1.0 | | 1.0 | | 1.0 | | 1.0 | |
| Construction | 0.5 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| Total Program | 10.2 | | 10.1 | | 11.1 | | 11.1 | | 11.1 | | 11.1 | | 11.1 | |
| Proposed Construction | 0.0 | | 0.0 | | 28.5 | | 0.5 | | 0.0 | | 0.0 | | 0.0 | |
| Direct Personnel | 78.2 | | 76.0 | | 76.2 | | 76.2 | | 76.2 | | 76.2 | | 76.2 | |

Table A.2 (continued)

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **KC01 Nuclear Sciences** | | | | | | | | | | | | | | |
| Internal Operating | | 13.4 | | 14.7 | | 17.3 | | 17.3 | | 17.3 | | 17.3 | | 17.3 |
| Procurement | | 0.6 | | 0.6 | | 0.7 | | 0.7 | | 0.7 | | 0.7 | | 0.7 |
| Total Operating | 13.8 | 14.1 | 17.4 | 15.3 | 20.0 | 18.0 | 20.0 | 18.0 | 20.0 | 18.0 | 20.0 | 18.0 | 20.0 | 18.0 |
| Capital Equipment | 0.6 | | 0.8 | | 1.4 | | 1.0 | | 1.0 | | 1.0 | | 1.0 | |
| Total Activity | 14.4 | | 18.2 | | 21.4 | | 20.9 | | 20.9 | | 20.9 | | 20.9 | |
| Proposed Construction | 0.0 | | 0.0 | | 0.5 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| Direct Personnel | 148.0 | | 150.2 | | 135.3 | | 135.3 | | 135.3 | | 135.3 | | 135.5 | |
| **KC02 Materials Sciences** | | | | | | | | | | | | | | |
| Internal Operating | | 17.7 | | 18.8 | | 21.7 | | 22.8 | | 24.0 | | 24.0 | | 24.0 |
| Procurement | | 1.2 | | 1.0 | | 1.1 | | 1.1 | | 1.1 | | 1.1 | | 1.1 |
| Total Operating | 18.8 | 19.0 | 20.8 | 19.8 | 23.4 | 22.8 | 24.6 | 24.0 | 25.8 | 25.2 | 25.8 | 25.2 | 25.8 | 25.2 |
| Capital Equipment | 2.1 | | 3.2 | | 4.6 | | 4.8 | | 5.1 | | 5.1 | | 5.1 | |
| Total Activity | 20.9 | | 24.0 | | 28.0 | | 29.4 | | 30.9 | | 30.9 | | 30.9 | |
| Proposed Construction | 0.0 | | 0.0 | | 3.0 | | 17.6 | | 0.0 | | 0.0 | | 0.0 | |
| Direct Personnel | 163.3 | | 158.1 | | 158.1 | | 158.1 | | 158.1 | | 158.1 | | 158.1 | |
| **KC03 Chemical Sciences** | | | | | | | | | | | | | | |
| Internal Operating | | 7.2 | | 7.7 | | 8.3 | | 8.4 | | 8.4 | | 8.4 | | 8.4 |
| Procurement | | 0.2 | | 0.2 | | 0.3 | | 0.2 | | 0.2 | | 0.2 | | 0.2 |
| Total Operating | 7.4 | 7.4 | 8.7 | 8.0 | 9.8 | 8.6 | 9.8 | 8.6 | 9.8 | 8.6 | 9.8 | 8.6 | 9.8 | 8.6 |
| Capital Equipment | 0.5 | | 0.9 | | 1.0 | | 1.0 | | 1.0 | | 1.0 | | 1.0 | |
| Total Activity | 7.9 | | 9.6 | | 10.7 | | 10.7 | | 10.7 | | 10.7 | | 10.7 | |
| Proposed Construction | 0.0 | | 0.0 | | 0.4 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| Direct Personnel | 74.9 | | 74.4 | | 74.4 | | 74.4 | | 74.4 | | 74.4 | | 74.4 | |

Table A.2 (continued)

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **KC04 Engineering, Math, and Geosciences** | | | | | | | | | | | | | | |
| Internal Operating | | 1.1 | | 1.3 | | 1.7 | | 1.9 | | 2.1 | | 2.3 | | 2.3 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 1.1 | 1.2 | 1.5 | 1.4 | 1.8 | 1.7 | 2.0 | 1.9 | 2.2 | 2.1 | 2.4 | 2.3 | 2.4 | 2.3 |
| Capital Equipment | 0.3 | | 0.2 | | 0.2 | | 0.2 | | 0.2 | | 0.2 | | 0.2 | |
| Total Activity | 1.4 | | 1.6 | | 2.0 | | 2.2 | | 2.4 | | 2.6 | | 2.6 | |
| Direct Personnel | 4.4 | | 5.6 | | 7.8 | | 7.8 | | 7.8 | | 7.8 | | 7.8 | |
| **KC06 Biological Energy Conversion** | | | | | | | | | | | | | | |
| Internal Operating | | 0.2 | | 0.2 | | 0.2 | | 0.4 | | 0.5 | | 0.6 | | 0.6 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.4 | 0.4 | 0.5 | 0.5 | 0.6 | 0.6 | 0.6 | 0.6 |
| Direct Personnel | 1.5 | | 2.0 | | 2.0 | | 2.0 | | 2.0 | | 2.0 | | 2.0 | |
| **KC07 Isotopes Production & Services** | | | | | | | | | | | | | | |
| Internal Operating | | 0.0 | | 0.0 | | 1.8 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.0 | 0.0 | 0.0 | 0.0 | 1.8 | 1.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Capital Equipment | 0.0 | | 0.0 | | 0.3 | | 0.3 | | 0.3 | | 0.3 | | 0.3 | |
| Total Activity | 0.0 | | 0.0 | | 2.1 | | 0.3 | | 0.3 | | 0.3 | | 0.3 | |
| Direct Personnel | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |

**Table A.2 (continued)**

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **KC BASIC ENERGY SCIENCES** | | | | | | | | | | | | | | |
| Internal Operating | | 39.6 | | 42.7 | | 51.1 | | 50.8 | | 52.3 | | 52.6 | | 52.6 |
| Procurement | | 2.1 | | 1.9 | | 2.1 | | 2.0 | | 2.0 | | 2.0 | | 2.0 |
| Total Operating | 41.2 | 41.8 | 48.6 | 44.6 | 57.0 | 53.2 | 56.7 | 52.9 | 58.2 | 54.4 | 58.6 | 54.7 | 58.6 | 54.7 |
| Capital Equipment | 3.5 | | 5.1 | | 7.4 | | 7.2 | | 7.4 | | 7.5 | | 7.5 | |
| Total Program | 44.8 | | 53.6 | | 64.4 | | 63.9 | | 65.7 | | 66.0 | | 66.0 | |
| Proposed Construction | 0.0 | | 0.0 | | 3.9 | | 17.6 | | 0.0 | | 0.0 | | 0.0 | |
| Direct Personnel | 392.1 | | 390.3 | | 377.6 | | 377.6 | | 377.6 | | 377.6 | | 377.8 | |
| **KD01 Assessment Projects** | | | | | | | | | | | | | | |
| Internal Operating | | 0.7 | | 0.8 | | 0.8 | | 0.8 | | 0.8 | | 0.8 | | 0.8 |
| Procurement | | 0.5 | | 0.4 | | 0.4 | | 0.4 | | 0.4 | | 0.4 | | 0.4 |
| Total Operating | 1.3 | 1.2 | 1.0 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 |
| Direct Personnel | 7.5 | | 7.5 | | 6.5 | | 6.5 | | 6.5 | | 6.5 | | 6.5 | |
| **KD04 Advanced Technology Projects** | | | | | | | | | | | | | | |
| Internal Operating | | 0.2 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 1.8 | | 0.3 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |

Table A.2 (continued)

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **KD TECHNOLOGY ASSESSMENT PROJECTS** | | | | | | | | | | | | | | |
| Internal Operating | | 0.9 | | 0.8 | | 0.8 | | 0.8 | | 0.8 | | 0.8 | | 0.8 |
| Procurement | | 0.5 | | 0.4 | | 0.4 | | 0.4 | | 0.4 | | 0.4 | | 0.4 |
| Total Operating | 1.3 | 1.5 | 1.0 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 |
| Direct Personnel | 9.3 | | 7.8 | | 6.5 | | 6.5 | | 6.5 | | 6.5 | | 6.5 | |
| **KE01 University Research Support** | | | | | | | | | | | | | | |
| Internal Operating | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 |
| Procurement | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 |
| Total Operating | 0.2 | 0.2 | 0.2 | 0.2 | 0.3 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Direct Personnel | 1.0 | | 1.0 | | 1.0 | | 1.0 | | 1.0 | | 1.0 | | 1.0 | |
| **KE UNIVERSITY RESEARCH SUPPORT** | | | | | | | | | | | | | | |
| Internal Operating | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 |
| Procurement | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 |
| Total Operating | 0.2 | 0.2 | 0.2 | 0.2 | 0.3 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Direct Personnel | 1.0 | | 1.0 | | 1.0 | | 1.0 | | 1.0 | | 1.0 | | 1.0 | |

Table A.2 (continued)

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **Office of Energy Research** | | | | | | | | | | | | | | |
| Internal Operating | | 110.1 | | 121.3 | | 136.2 | | 138.4 | | 139.9 | | 140.2 | | 140.2 |
| Procurement | | 27.0 | | 21.3 | | 29.3 | | 29.3 | | 29.3 | | 29.3 | | 29.3 |
| Total Operating | 135.9 | 137.1 | 146.8 | 142.6 | 178.5 | 165.5 | 172.0 | 167.7 | 173.5 | 169.2 | 173.8 | 169.5 | 173.8 | 169.5 |
| Capital Equipment | 16.0 | | 20.1 | | 17.5 | | 17.4 | | 17.8 | | 17.9 | | 18.0 | |
| Construction | 20.9 | | 0.0 | | 25.0 | | 45.0 | | 27.0 | | 4.2 | | 0.0 | |
| Total Asst Secretary | 172.8 | | 166.9 | | 221.0 | | 234.4 | | 218.3 | | 195.9 | | 191.8 | |
| Proposed Construction | 0.0 | | 1.6 | | 32.4 | | 24.1 | | 16.3 | | 27.7 | | 0.0 | |
| Direct Personnel | 889.4 | | 861.2 | | 862.6 | | 873.6 | | 878.6 | | 878.6 | | 878.8 | |
| **Assistant Secretary for Defense Programs** | | | | | | | | | | | | | | |
| **AR05 Defense Waste Management Programs** | | | | | | | | | | | | | | |
| Internal Operating | | 14.2 | | 15.2 | | 17.0 | | 16.8 | | 18.5 | | 19.5 | | 19.4 |
| Procurement | | 2.2 | | 2.4 | | 2.1 | | 1.8 | | 2.1 | | 2.8 | | 2.8 |
| Total Operating | 15.7 | 16.3 | 18.1 | 17.6 | 19.2 | 19.1 | 18.9 | 18.5 | 21.0 | 20.5 | 22.2 | 22.3 | 22.2 | 22.2 |
| Capital Equipment | 0.5 | | 1.3 | | 1.5 | | 0.8 | | 0.9 | | 0.8 | | 0.8 | |
| Construction | 7.8 | | 5.0 | | 4.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| Total Activity | 24.0 | | 24.4 | | 24.7 | | 19.7 | | 21.9 | | 23.0 | | 23.0 | |
| Proposed Construction | 0.0 | | 2.0 | | 2.0 | | 8.0 | | 11.0 | | 12.0 | | 7.0 | |
| Direct Personnel | 121.9 | | 114.3 | | 143.0 | | 150.0 | | 151.7 | | 151.5 | | 157.0 | |

Table A.2 (continued)

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **AR DEFENSE WASTE MANAGEMENT** | | | | | | | | | | | | | | |
| Internal Operating | | 14.2 | | 15.2 | | 17.0 | | 16.8 | | 18.5 | | 19.5 | | 19.4 |
| Procurement | | 2.2 | | 2.4 | | 2.1 | | 1.8 | | 2.1 | | 2.8 | | 2.8 |
| Total Operating | 15.7 | 16.3 | 18.1 | 17.6 | 19.2 | 19.1 | 18.9 | 18.5 | 21.0 | 20.5 | 22.2 | 22.3 | 22.2 | 22.2 |
| Capital Equipment | 0.5 | | 1.3 | | 1.5 | | 0.8 | | 0.9 | | 0.8 | | 0.8 | |
| Construction | 7.8 | | 5.0 | | 4.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| Total Program | 24.0 | | 24.4 | | 24.7 | | 19.7 | | 21.9 | | 23.0 | | 23.0 | |
| Proposed Construction | 0.0 | | 2.0 | | 2.0 | | 8.0 | | 11.0 | | 12.0 | | 7.0 | |
| Direct Personnel | 121.9 | | 114.3 | | 143.0 | | 150.0 | | 151.7 | | 151.5 | | 157.0 | |
| **GB01 Research Development & Testing** | | | | | | | | | | | | | | |
| Internal Operating | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Direct Personnel | 0.8 | | 1.0 | | 1.0 | | 1.0 | | 1.0 | | 1.0 | | 1.0 | |
| **GB WEAPONS ACTIVITIES** | | | | | | | | | | | | | | |
| Internal Operating | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Direct Personnel | 0.8 | | 1.0 | | 1.0 | | 1.0 | | 1.0 | | 1.0 | | 1.0 | |

Table A.2 (continued)

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **GC01 Verification and Control Technology** | | | | | | | | | | | | | | |
| Internal Operating | | 0.1 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | | 0.7 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 |
| **GC VERIFICATION & CONTROL TECHNOLOGY** | | | | | | | | | | | | | | |
| Internal Operating | | 0.1 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | | 0.7 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 |
| **GD01 Nuclear Matls.Security & Safeguards** | | | | | | | | | | | | | | |
| Internal Operating | | 0.2 | | 0.1 | | 0.1 | | 0.2 | | 0.2 | | 0.2 | | 0.2 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.2 | 0.2 | 0.2 | 0.1 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.3 | 0.3 |
| Construction | 3.1 | | 2.2 | | 2.2 | | 0.9 | | 0.0 | | 0.0 | | 0.0 | |
| Total Activity | 3.3 | | 2.3 | | 2.4 | | 1.2 | | 0.2 | | 0.3 | | 0.3 | |
| Direct Personnel | | 1.3 | | 1.3 | | 1.3 | | 1.5 | | 1.7 | | 2.0 | | 2.2 |

Table A.2 (continued)

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **GD NUCLEAR MATLS SECURITY & SAFEGUARDS** | | | | | | | | | | | | | | |
| Internal Operating | | 0.2 | | 0.1 | | 0.1 | | 0.2 | | 0.2 | | 0.2 | | 0.2 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.2 | 0.2 | 0.2 | 0.1 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.3 | 0.3 |
| Construction | 3.1 | | 2.2 | | 2.2 | | 0.9 | | 0.0 | | 0.0 | | 0.0 | |
| Total Program | 3.3 | | 2.3 | | 2.4 | | 1.2 | | 0.2 | | 0.3 | | 0.3 | |
| Direct Personnel | 1.3 | | 1.3 | | 1.3 | | 1.5 | | 1.7 | | 2.0 | | 2.2 | |
| **GE03 Supporting Services** | | | | | | | | | | | | | | |
| Internal Operating | | 4.1 | | 3.3 | | 3.8 | | 3.9 | | 4.1 | | 2.4 | | 2.6 |
| Procurement | | 1.8 | | 1.6 | | 0.6 | | 0.5 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 5.2 | 5.9 | 5.6 | 4.9 | 4.3 | 4.4 | 4.3 | 4.4 | 3.6 | 4.1 | 2.5 | 2.4 | 2.7 | 2.6 |
| Capital Equipment | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | |
| Total Activity | 5.3 | | 5.7 | | 4.5 | | 4.4 | | 3.7 | | 2.6 | | 2.8 | |
| Direct Personnel | 46.0 | | 30.4 | | 29.8 | | 29.0 | | 29.0 | | 20.0 | | 20.0 | |
| **GE MATERIALS PRODUCTION** | | | | | | | | | | | | | | |
| Internal Operating | | 4.1 | | 3.3 | | 3.8 | | 3.9 | | 4.1 | | 2.4 | | 2.6 |
| Procurement | | 1.8 | | 1.6 | | 0.6 | | 0.5 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 5.2 | 5.9 | 5.6 | 4.9 | 4.3 | 4.4 | 4.3 | 4.4 | 3.6 | 4.1 | 2.5 | 2.4 | 2.7 | 2.6 |
| Capital Equipment | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | |
| Total Program | 5.3 | | 5.7 | | 4.5 | | 4.4 | | 3.7 | | 2.6 | | 2.8 | |
| Direct Personnel | 46.0 | | 30.4 | | 29.8 | | 29.0 | | 29.0 | | 20.0 | | 20.0 | |

Table A.2 (continued)

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **Assistant Secretary for Defense Programs** | | | | | | | | | | | | | | |
| Internal Operating | | 18.6 | | 18.8 | | 21.0 | | 21.0 | | 22.9 | | 22.2 | | 22.4 |
| Procurement | | 4.0 | | 4.0 | | 2.7 | | 2.3 | | 2.1 | | 2.9 | | 2.9 |
| Total Operating | 21.3 | 22.5 | 24.0 | 22.8 | 23.9 | 23.8 | 23.6 | 23.3 | 25.0 | 25.0 | 25.0 | 25.1 | 25.3 | 25.2 |
| Capital Equipment | 0.6 | | 1.4 | | 1.7 | | 0.9 | | 1.0 | | 0.9 | | 0.9 | |
| Construction | 10.9 | | 7.2 | | 6.2 | | 0.9 | | 0.0 | | 0.0 | | 0.0 | |
| Total Asst Secretary | 32.7 | | 32.6 | | 31.7 | | 25.4 | | 26.0 | | 26.0 | | 26.3 | |
| Proposed Construction | 0.0 | | 2.0 | | 2.0 | | 8.0 | | 11.0 | | 12.0 | | 7.0 | |
| Direct Personnel | 170.7 | | 147.1 | | 175.2 | | 181.6 | | 183.5 | | 174.6 | | 180.3 | |
| **AS for Env.Protection,Safety & Emerg. Prep** | | | | | | | | | | | | | | |
| **EF07 Emergency Energy Conservation Prog** | | | | | | | | | | | | | | |
| Internal Operating | | 0.1 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 0.6 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| **EF STATE/LOCAL PROGRAMS** | | | | | | | | | | | | | | |
| Internal Operating | | 0.4 | | 0.3 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.4 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.4 | 0.8 | 0.0 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 4.1 | | 2.9 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |

Table A.2 (continued)

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **HA01 Overview and Assessment** | | | | | | | | | | | | | | |
| Internal Operating | | 4.4 | | 2.9 | | 3.1 | | 3.1 | | 3.1 | | 3.1 | | 3.1 |
| Procurement | | 1.7 | | 1.1 | | 0.9 | | 0.9 | | 0.9 | | 0.9 | | 0.9 |
| Total Operating | 5.8 | 6.1 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| Capital Equipment | 0.0 | | 0.2 | | 0.2 | | 0.2 | | 0.2 | | 0.2 | | 0.2 | |
| Total Activity | 5.8 | | 4.2 | | 4.2 | | 4.2 | | 4.2 | | 4.2 | | 4.2 | |
| Direct Personnel | 36.5 | | 24.0 | | 20.0 | | 20.0 | | 20.0 | | 20.0 | | 20.0 | |
| **HA05 Biological & Environmental Research** | | | | | | | | | | | | | | |
| Internal Operating | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.1 | 0.1 | 0.1 | 0.1 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Capital Equipment | 0.0 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | |
| Total Activity | 0.1 | | 0.2 | | 0.2 | | 0.2 | | 0.2 | | 0.2 | | 0.2 | |
| Direct Personnel | 0.7 | | 1.0 | | 1.0 | | 1.0 | | 1.0 | | 1.0 | | 1.0 | |
| **HA ENVIRONMENTAL RES & DEVELOPMENT** | | | | | | | | | | | | | | |
| Internal Operating | | 23.3 | | 19.7 | | 21.4 | | 22.9 | | 22.9 | | 22.9 | | 22.9 |
| Procurement | | 3.3 | | 2.4 | | 2.7 | | 2.7 | | 2.7 | | 2.7 | | 2.7 |
| Total Operating | 26.1 | 26.6 | 20.6 | 22.1 | 24.7 | 24.1 | 25.6 | 25.6 | 25.6 | 25.6 | 25.6 | 25.6 | 25.6 | 25.6 |
| Capital Equipment | 1.6 | | 1.8 | | 1.8 | | 2.0 | | 2.1 | | 2.2 | | 2.3 | |
| Construction | 1.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| Total Program | 28.7 | | 22.4 | | 26.5 | | 27.6 | | 27.7 | | 27.8 | | 27.9 | |
| Proposed Construction | 0.0 | | 1.6 | | 0.0 | | 6.0 | | 16.3 | | 27.7 | | 0.0 | |
| Direct Personnel | 200.2 | | 155.0 | | 161.0 | | 166.0 | | 171.0 | | 171.0 | | 171.0 | |

**Table A.2 (continued)**

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **SA01 Planning** | | | | | | | | | | | | | | |
| Internal Operating | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| 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 |
| Direct Personnel | 0.2 | | 0.1 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| **SA STRATEGIC PETROLEUM RESERVE** | | | | | | | | | | | | | | |
| Internal Operating | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| 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 |
| Direct Personnel | 0.2 | | 0.1 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| **UB02 Power Supply & Reliability** | | | | | | | | | | | | | | |
| Internal Operating | | 0.2 | | 0.2 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.2 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.0 | 0.4 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 1.8 | | 1.7 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |

Table A.2 (continued)

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **UB UTILITY PROG & REGULATORY INTERVEN** | | | | | | | | | | | | | | |
| Internal Operating | | 0.2 | | 0.2 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.2 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.0 | 0.4 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 1.8 | | 1.7 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| **UE04 Env Protect Safety & Emerg Prep** | | | | | | | | | | | | | | |
| Internal Operating | | 0.0 | | 0.2 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 0.2 | | 1.5 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| **UE FUELS REGULATION** | | | | | | | | | | | | | | |
| Internal Operating | | 0.0 | | 0.3 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 0.2 | | 1.5 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |

Table A.2 (continued)

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **AS for Env.Protection,Safety & Emerg. Prep** | | | | | | | | | | | | | | |
| Internal Operating | | 4.8 | | 3.5 | | 3.2 | | 3.2 | | 3.2 | | 3.2 | | 3.2 |
| Procurement | | 1.9 | | 1.1 | | 0.9 | | 0.9 | | 0.9 | | 0.9 | | 0.9 |
| Total Operating | 5.9 | 6.7 | 4.1 | 4.6 | 4.2 | 4.1 | 4.1 | 4.1 | 4.1 | 4.1 | 4.1 | 4.1 | 4.1 | 4.1 |
| Capital Equipment | 0.0 | | 0.3 | | 0.2 | | 0.3 | | 0.3 | | 0.3 | | 0.3 | |
| Total Asst Secretary | 5.9 | | 4.5 | | 4.4 | | 4.4 | | 4.4 | | 4.4 | | 4.4 | |
| Direct Personnel | 40.0 | | 28.3 | | 21.0 | | 21.0 | | 21.0 | | 21.0 | | 21.0 | |
| **Federal Energy Regulatory Commission** | | | | | | | | | | | | | | |
| **VI01 Contractual Activity** | | | | | | | | | | | | | | |
| Internal Operating | | 0.0 | | 0.5 | | 0.6 | | 0.6 | | 0.6 | | 0.6 | | 0.6 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.0 | 0.0 | 0.7 | 0.5 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| Direct Personnel | 0.0 | | 3.0 | | 3.0 | | 3.0 | | 3.0 | | 3.0 | | 3.0 | |
| **VI OTHER SERVICES** | | | | | | | | | | | | | | |
| Internal Operating | | 0.0 | | 0.5 | | 0.6 | | 0.6 | | 0.6 | | 0.6 | | 0.6 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.0 | 0.0 | 0.7 | 0.5 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| Direct Personnel | 0.0 | | 3.0 | | 3.0 | | 3.0 | | 3.0 | | 3.0 | | 3.0 | |

Table A.2 (continued)

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **Federal Energy Regulatory Commission** | | | | | | | | | | | | | | |
| Internal Operating | | 0.0 | | 0.5 | | 0.6 | | 0.6 | | 0.6 | | 0.6 | | 0.6 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.0 | 0.0 | 0.7 | 0.5 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| Direct Personnel | 0.0 | | 3.0 | | 3.0 | | 3.0 | | 3.0 | | 3.0 | | 3.0 | |
| **Economic Regulatory Administration** | | | | | | | | | | | | | | |
| **UA01 Contractual Activity** | | | | | | | | | | | | | | |
| Internal Operating | | 0.1 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 0.1 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| **UA FUELS CONVERSION** | | | | | | | | | | | | | | |
| Internal Operating | | 0.1 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 0.1 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |

Table A.2 (continued)

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **UB01 Utility Regulatory Assistance** | | | | | | | | | | | | | | |
| Internal Operating | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| 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 |
| Direct Personnel | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| **UB UTILITY PROG & REGULATORY INTERVEN** | | | | | | | | | | | | | | |
| Internal Operating | | 0.2 | | 0.2 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.2 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.0 | 0.4 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 1.8 | | 1.7 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| **UC01 Office of Special Counsel** | | | | | | | | | | | | | | |
| Internal Operating | | 0.1 | | 0.2 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.3 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.0 | 0.4 | 0.1 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 0.8 | | 1.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |

Table A.2 (continued)

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **UC COMPLIANCE** | | | | | | | | | | | | | | |
| Internal Operating | | 0.1 | | 0.2 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.3 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.0 | 0.4 | 0.1 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 0.8 | | 1.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| **UE03 Economic Regulatory Administration** | | | | | | | | | | | | | | |
| Internal Operating | | 0.0 | | 0.1 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| **UE FUELS REGULATION** | | | | | | | | | | | | | | |
| Internal Operating | | 0.0 | | 0.3 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 0.2 | | 1.5 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |

**Table A.2 (continued)**

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **Economic Regulatory Administration** | | | | | | | | | | | | | | |
| Internal Operating | | 0.2 | | 0.2 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.3 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.0 | 0.4 | 0.1 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 0.9 | | 1.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| **Energy Information Adminstration** | | | | | | | | | | | | | | |
| **TA01 Program Prime Procurement** | | | | | | | | | | | | | | |
| Internal Operating | | 0.5 | | 3.5 | | 5.0 | | 5.0 | | 5.0 | | 5.0 | | 5.0 |
| Procurement | | 2.4 | | 5.8 | | 4.0 | | 4.0 | | 4.0 | | 4.0 | | 4.0 |
| Total Operating | 8.6 | 3.0 | 8.0 | 9.3 | 9.0 | 9.0 | 9.0 | 9.0 | 9.0 | 9.0 | 9.0 | 9.0 | 9.0 | 9.0 |
| Capital Equipment | 0.0 | | 0.2 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | |
| Total Activity | 8.6 | | 8.2 | | 9.1 | | 9.1 | | 9.1 | | 9.1 | | 9.1 | |
| Direct Personnel | 4.7 | | 22.5 | | 30.0 | | 30.0 | | 30.0 | | 30.0 | | 30.0 | |
| **TA ENERGY APPLIED ANALYSIS** | | | | | | | | | | | | | | |
| Internal Operating | | 0.5 | | 3.5 | | 5.0 | | 5.0 | | 5.0 | | 5.0 | | 5.0 |
| Procurement | | 2.4 | | 5.8 | | 4.0 | | 4.0 | | 4.0 | | 4.0 | | 4.0 |
| Total Operating | 8.6 | 3.0 | 8.0 | 9.3 | 9.0 | 9.0 | 9.0 | 9.0 | 9.0 | 9.0 | 9.0 | 9.0 | 9.0 | 9.0 |
| Capital Equipment | 0.0 | | 0.2 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | |
| Total Program | 8.6 | | 8.2 | | 9.1 | | 9.1 | | 9.1 | | 9.1 | | 9.1 | |
| Direct Personnel | 4.7 | | 22.5 | | 30.0 | | 30.0 | | 30.0 | | 30.0 | | 30.0 | |

Table A.2 (continued)

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **TB01 Program Prime Procurement** | | | | | | | | | | | | | | |
| Internal Operating | | 0.1 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.9 | | 0.5 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 1.1 | 0.9 | 0.0 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 0.5 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| **TB03 ADP Prime Procurement** | | | | | | | | | | | | | | |
| Internal Operating | | 0.2 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.2 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.0 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 0.7 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| **TB COLLECTION, PRODUCTION & DISSEMIN** | | | | | | | | | | | | | | |
| Internal Operating | | 0.3 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 1.1 | | 0.5 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 1.1 | 1.3 | 0.0 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 1.2 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |

Table A.2 (continued)

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **TC01 Program Prime Procurement** | | | | | | | | | | | | | | |
| Internal Operating | | 0.7 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 2.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.1 | 2.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 5.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| **TC03 ADP Prime Procurement** | | | | | | | | | | | | | | |
| Internal Operating | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| 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 |
| Direct Personnel | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| **TC DATA VALIDATION** | | | | | | | | | | | | | | |
| Internal Operating | | 0.7 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 2.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.1 | 2.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 5.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |

Table A.2 (continued)

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **TD03 ADP Prime Procurement** | | | | | | | | | | | | | | |
| Internal Operating | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.2 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 0.1 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| **TD DATA INFORMATION SERVICES** | | | | | | | | | | | | | | |
| Internal Operating | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Procurement | | 0.2 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Direct Personnel | 0.1 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| **Energy Information Adminstration** | | | | | | | | | | | | | | |
| Internal Operating | | 1.5 | | 3.5 | | 5.0 | | 5.0 | | 5.0 | | 5.0 | | 5.0 |
| Procurement | | 5.7 | | 6.3 | | 4.0 | | 4.0 | | 4.0 | | 4.0 | | 4.0 |
| Total Operating | 9.7 | 7.2 | 8.0 | 9.8 | 9.0 | 9.0 | 9.0 | 9.0 | 9.0 | 9.0 | 9.0 | 9.0 | 9.0 | 9.0 |
| Capital Equipment | 0.0 | | 0.2 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | |
| Total Asst Secretary | 9.7 | | 8.2 | | 9.1 | | 9.1 | | 9.1 | | 9.1 | | 9.1 | |
| Direct Personnel | 11.0 | | 22.5 | | 30.0 | | 30.0 | | 30.0 | | 30.0 | | 30.0 | |

**Table A.2 (continued)**

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **Asst. Sec. for Management & Administration** | | | | | | | | | | | | | | |
| **LA01 Technical Information Center** | | | | | | | | | | | | | | |
| Internal Operating | | 0.8 | | 0.8 | | 0.8 | | 0.8 | | 0.8 | | 0.8 | | 0.8 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| 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 |
| Capital Equipment | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | |
| Total Activity | 0.9 | | 0.9 | | 0.9 | | 0.9 | | 0.9 | | 0.9 | | 0.9 | |
| Direct Personnel | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| **LA TECHNICAL INFORMATION SERVICES** | | | | | | | | | | | | | | |
| Internal Operating | | 0.8 | | 0.8 | | 0.8 | | 0.8 | | 0.8 | | 0.8 | | 0.8 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| 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 |
| Capital Equipment | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | |
| Total Program | 0.9 | | 0.9 | | 0.9 | | 0.9 | | 0.9 | | 0.9 | | 0.9 | |
| Direct Personnel | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| **Asst. Sec. for Management & Administration** | | | | | | | | | | | | | | |
| Internal Operating | | 0.8 | | 0.8 | | 0.8 | | 0.8 | | 0.8 | | 0.8 | | 0.8 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| 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 |
| Capital Equipment | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | |
| Total Asst Secretary | 0.9 | | 0.9 | | 0.9 | | 0.9 | | 0.9 | | 0.9 | | 0.9 | |
| Direct Personnel | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |

Table A.2 (continued)

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **DOE CONTRACTORS & OPERATIONS OFFICE** | | | | | | | | | | | | | | |
| **DOE CONTRACTORS & OPERATIONS OFFICE** | | | | | | | | | | | | | | |
| Internal Operating | | 7.8 | | 4.4 | | 3.3 | | 1.8 | | 2.3 | | 4.2 | | 5.4 |
| Procurement | | 0.1 | | 0.5 | | 1.5 | | 1.6 | | 1.7 | | 0.8 | | 0.6 |
| Total Operating | 7.5 | 8.0 | 5.8 | 4.8 | 3.8 | 4.8 | 3.4 | 3.4 | 3.9 | 3.9 | 5.0 | 5.0 | 6.0 | 6.0 |
| Direct Personnel | 51.3 | | 33.3 | | 25.0 | | 21.2 | | 24.3 | | 29.3 | | 39.3 | |
| **Work for Others** | | | | | | | | | | | | | | |
| **NRC/Nuclear Reactor Regulation** | | | | | | | | | | | | | | |
| Internal Operating | | 4.0 | | 3.3 | | 3.6 | | 3.6 | | 3.6 | | 3.6 | | 3.6 |
| Procurement | | 0.6 | | 0.6 | | 0.5 | | 0.5 | | 0.5 | | 0.5 | | 0.5 |
| Total Operating | 4.8 | 4.6 | 3.8 | 3.9 | 4.2 | 4.2 | 4.2 | 4.2 | 4.2 | 4.2 | 4.2 | 4.2 | 4.2 | 4.2 |
| Direct Personnel | 38.9 | | 37.0 | | 38.4 | | 38.4 | | 38.4 | | 38.4 | | 38.4 | |
| **NRC/Administration** | | | | | | | | | | | | | | |
| Internal Operating | | 0.3 | | 0.3 | | 0.4 | | 0.4 | | 0.4 | | 0.4 | | 0.4 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.3 | 0.3 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 |
| Direct Personnel | 2.7 | | 2.7 | | 2.7 | | 2.7 | | 2.7 | | 2.7 | | 2.7 | |

**Table A.2 (continued)**

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **NRC/Nuc Mat Safety & Safeguards** | | | | | | | | | | | | | | |
| Internal Operating | | 1.3 | | 1.8 | | 1.7 | | 1.7 | | 1.7 | | 1.7 | | 1.7 |
| Procurement | | 0.4 | | 0.2 | | 0.2 | | 0.2 | | 0.2 | | 0.2 | | 0.2 |
| Total Operating | 1.8 | 1.7 | 1.6 | 2.0 | 1.3 | 1.9 | 1.3 | 1.9 | 1.3 | 1.9 | 1.3 | 1.9 | 1.3 | 1.9 |
| Direct Personnel | 10.7 | | 12.9 | | 9.7 | | 9.7 | | 9.7 | | 9.7 | | 9.7 | |
| **NRC/Nuclear Regulatory Research** | | | | | | | | | | | | | | |
| Internal Operating | | 15.7 | | 16.7 | | 15.5 | | 15.5 | | 15.5 | | 15.5 | | 15.5 |
| Procurement | | 5.6 | | 5.4 | | 3.8 | | 3.8 | | 3.8 | | 3.8 | | 3.8 |
| Total Operating | 21.6 | 21.4 | 21.3 | 22.2 | 22.4 | 19.2 | 22.4 | 19.2 | 22.4 | 19.2 | 22.4 | 19.2 | 22.4 | 19.2 |
| Capital Equipment | 1.2 | | 0.9 | | 0.8 | | 0.8 | | 0.8 | | 0.8 | | 0.8 | |
| Total Activity | 22.8 | | 22.2 | | 23.2 | | 23.2 | | 23.2 | | 23.2 | | 23.2 | |
| Direct Personnel | 120.3 | | 128.2 | | 108.9 | | 108.9 | | 108.9 | | 108.9 | | 108.9 | |
| **NRC/Analysis & Eval of Oper Data** | | | | | | | | | | | | | | |
| Internal Operating | | 1.6 | | 1.5 | | 1.5 | | 1.5 | | 1.5 | | 1.5 | | 1.5 |
| Procurement | | 0.2 | | 0.2 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 |
| Total Operating | 1.8 | 1.8 | 1.7 | 1.7 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 |
| Direct Personnel | 12.6 | | 10.1 | | 9.3 | | 9.3 | | 9.3 | | 9.3 | | 9.3 | |

Table A.2 (continued)

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **NRC/Other Offices** | | | | | | | | | | | | | | |
| Internal Operating | | 0.2 | | 0.4 | | 0.2 | | 0.2 | | 0.2 | | 0.2 | | 0.2 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 0.3 | 0.2 | 0.3 | 0.4 | 0.3 | 0.2 | 0.3 | 0.2 | 0.3 | 0.2 | 0.3 | 0.2 | 0.3 | 0.2 |
| Direct Personnel | 3.5 | | 4.0 | | 1.5 | | 1.5 | | 1.5 | | 1.5 | | 1.5 | |
| **NUCLEAR REGULATORY COMMISSION** | | | | | | | | | | | | | | |
| Internal Operating | | 23.2 | | 24.0 | | 22.9 | | 22.9 | | 22.9 | | 22.9 | | 22.9 |
| Procurement | | 6.9 | | 6.4 | | 4.6 | | 4.6 | | 4.6 | | 4.6 | | 4.6 |
| Total Operating | 30.6 | 30.1 | 29.0 | 30.5 | 30.2 | 27.5 | 30.2 | 27.5 | 30.2 | 27.5 | 30.2 | 27.5 | 30.2 | 27.5 |
| Capital Equipment | 1.3 | | 0.9 | | 0.8 | | 0.8 | | 0.8 | | 0.8 | | 0.8 | |
| Total Program | 31.9 | | 30.0 | | 31.1 | | 31.1 | | 31.1 | | 31.1 | | 31.1 | |
| Direct Personnel | 188.7 | | 194.9 | | 170.5 | | 170.5 | | 170.5 | | 170.5 | | 170.5 | |
| **DEPARTMENT OF DEFENSE** | | | | | | | | | | | | | | |
| Internal Operating | | 3.8 | | 4.7 | | 4.5 | | 4.6 | | 4.8 | | 5.0 | | 5.1 |
| Procurement | | 0.2 | | 0.2 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 |
| Total Operating | 4.0 | 4.0 | 4.9 | 4.9 | 4.6 | 4.6 | 4.7 | 4.7 | 4.9 | 4.9 | 5.1 | 5.1 | 5.2 | 5.2 |
| Capital Equipment | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | |
| Total Program | 4.1 | | 4.9 | | 4.6 | | 4.8 | | 5.0 | | 5.1 | | 5.3 | |
| Direct Personnel | 40.4 | | 45.0 | | 42.0 | | 42.8 | | 43.8 | | 43.8 | | 44.8 | |

**Table A.2 (continued)**

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **DEPARTMENT OF INTERIOR** | | | | | | | | | | | | | | |
| Internal Operating | | 0.7 | | 0.6 | | 0.5 | | 0.6 | | 0.6 | | 0.6 | | 0.6 |
| Procurement | | 0.8 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 1.5 | 1.5 | 0.4 | 0.6 | 0.5 | 0.5 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| Direct Personnel | 4.0 | | 4.8 | | 3.6 | | 4.1 | | 4.1 | | 4.1 | | 4.1 | |
| **DEPT. OF HEALTH & HUMAN SERVICES** | | | | | | | | | | | | | | |
| Internal Operating | | 5.6 | | 4.8 | | 4.9 | | 5.1 | | 5.2 | | 5.4 | | 5.6 |
| Procurement | | 0.4 | | 0.3 | | 0.3 | | 0.3 | | 0.3 | | 0.3 | | 0.3 |
| Total Operating | 5.9 | 5.9 | 5.1 | 5.1 | 5.2 | 5.2 | 5.4 | 5.4 | 5.5 | 5.5 | 5.7 | 5.7 | 5.9 | 5.9 |
| Direct Personnel | 58.2 | | 52.6 | | 50.8 | | 52.0 | | 53.0 | | 54.0 | | 55.0 | |
| **ENVIRONMENTAL PROTECTION AGENCY** | | | | | | | | | | | | | | |
| Internal Operating | | 5.9 | | 5.8 | | 5.0 | | 5.0 | | 5.0 | | 5.0 | | 5.0 |
| Procurement | | 0.3 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 |
| Total Operating | 6.1 | 6.1 | 5.8 | 5.8 | 5.1 | 5.1 | 5.1 | 5.1 | 5.1 | 5.1 | 5.1 | 5.1 | 5.1 | 5.1 |
| Direct Personnel | 60.0 | | 55.1 | | 44.7 | | 45.0 | | 45.0 | | 45.1 | | 45.0 | |

Table A.2 (continued)

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **NATIONAL SCIENCE FOUNDATION** | | | | | | | | | | | | | | |
| Internal Operating | | 1.8 | | 1.8 | | 1.9 | | 2.0 | | 2.1 | | 2.2 | | 2.3 |
| Procurement | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 |
| Total Operating | 1.8 | 1.8 | 1.9 | 1.9 | 2.0 | 2.0 | 2.1 | 2.1 | 2.2 | 2.2 | 2.2 | 2.2 | 2.3 | 2.3 |
| Direct Personnel | 15.9 | | 17.3 | | 16.5 | | 17.0 | | 18.0 | | 18.0 | | 18.0 | |
| **TENNESSEE VALLEY AUTHORITY** | | | | | | | | | | | | | | |
| Internal Operating | | 1.1 | | 1.1 | | 0.7 | | 0.7 | | 0.6 | | 0.6 | | 0.6 |
| Procurement | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| Total Operating | 1.1 | 1.1 | 1.1 | 1.1 | 0.7 | 0.7 | 0.7 | 0.7 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| Direct Personnel | 8.2 | | 7.4 | | 6.0 | | 5.7 | | 5.1 | | 5.3 | | 5.3 | |
| **OTHER FEDERAL AGENCIES** | | | | | | | | | | | | | | |
| Internal Operating | | 3.5 | | 4.5 | | 5.2 | | 5.4 | | 5.6 | | 5.7 | | 5.7 |
| Procurement | | 0.1 | | 0.1 | | 0.0 | | 0.1 | | 0.1 | | 0.1 | | 0.1 |
| Total Operating | 3.5 | 3.6 | 4.6 | 4.6 | 5.3 | 5.3 | 5.5 | 5.5 | 5.6 | 5.6 | 5.8 | 5.8 | 5.8 | 5.8 |
| Direct Personnel | 37.1 | | 42.6 | | 47.6 | | 48.7 | | 49.6 | | 50.1 | | 50.1 | |

Table A.2 (continued)

| | FY 1982 | | FY 1983[a] | | FY 1984[a] | | FY 1985[a] | | FY 1986 | | FY 1987 | | FY 1988 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO | BA | BO |
| **ELECTRIC POWER RESEARCH INSTITUTE** | | | | | | | | | | | | | | |
| Internal Operating | | 2.0 | | 2.2 | | 2.5 | | 2.5 | | 2.5 | | 2.5 | | 2.5 |
| Procurement | | 0.0 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | | 0.1 |
| Total Operating | 2.1 | 2.1 | 2.2 | 2.2 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 |
| Direct Personnel | 20.0 | | 20.0 | | 22.0 | | 22.0 | | 22.0 | | 22.0 | | 22.0 | |
| **OTHER NONFEDERAL AGENCIES** | | | | | | | | | | | | | | |
| Internal Operating | | 2.1 | | 1.7 | | 1.7 | | 2.7 | | 3.4 | | 3.5 | | 3.5 |
| Procurement | | 0.3 | | 0.3 | | 0.3 | | 0.3 | | 0.3 | | 0.3 | | 0.3 |
| Total Operating | 2.3 | 2.3 | 2.0 | 2.0 | 2.0 | 2.0 | 3.0 | 3.0 | 3.7 | 3.7 | 3.8 | 3.8 | 3.8 | 3.8 |
| Capital Equipment | 0.0 | | 0.0 | | 0.0 | | 0.1 | | 0.1 | | 0.1 | | 0.1 | |
| Total Program | 2.3 | | 2.1 | | 2.0 | | 3.1 | | 3.8 | | 3.9 | | 3.9 | |
| Direct Personnel | 18.5 | | 18.2 | | 16.6 | | 24.5 | | 31.0 | | 31.0 | | 31.0 | |

**Table A.3. WPAS cross reference[a]**

| B&R Code | WPAS No. | WPAS Title |
|---|---|---|
| | | Assistant Secretary for Fossil Energy |
| AA0515000 | 00207 | Assess of Boiler Air Pollution |
| | 00211 | FE Solid Waste Extractions |
| AA1505000 | 00157 | Ceramic HX for Foss Fuel Combustion |
| AA1510100 | 00028 | AR&TD Fossil Energy Mtls Program |
| AA1515050 | 00214 | MPC Phase II Monitoring |
| | 00231 | METC: WWT PDU |
| AA1515100 | 00084 | Process Research Digest |
| | 00208 | Selective Ben & SCT Liquefaction |
| | 00209 | Indirect Liquefaction Chem Res |
| | 00302 | New Liquefaction Techniques |
| | 00305 | Physical Properties of Coal Liquids |
| AA1520151 | 00227 | Liq Econ & Tech Assmts |
| | 00230 | Letdown Flow Analysis |
| | 00311 | IEA - EA Service |
| | 00316 | Systems Analysis Support - LTAS |
| | 00324 | Performance Assurance & Stand |
| AA1520152 | 00204 | Envir Control Tech (ECT) Assess |
| | 00213 | Liquefaction ECT Assessments |
| | 00223 | Regulatory/Update (Newsletter) |
| | 00228 | FE Envir Safety & Health |
| AA1520153 | 00205 | GEMS/Liquid-Gaseous Fuel Supplies |
| AA2520000 | 00209 | Ind Lique Chem Res |
| AA2530100 | 00216 | Eff of Hydrotreat & Mitig Prog |
| | 00217 | Fluid Properties for Component Design |
| | 00220 | On-Line Monit Coal Liqu Solv |
| | 00221 | Impulse Line Plugging |
| | 00222 | Liq Plant Control Studies |
| | 00225 | Indirect Coal Liquefaction |
| AA3505100 | 00202 | OMS Probe |
| AA3505150 | 00212 | FBC Activity in India |
| AA3505300 | 00229 | Carbon Utilization Improvement |
| AA3505400 | 00017 | Coal Combustor for Cogeneration |
| AA3510100 | 00326 | Systems Assessment of PFBC |
| AA3510150 | 00326 | Systems Assessment of PFBC |
| AA3520100 | 00326 | Systems Assessment of PFBC |
| AA3525050 | 00326 | Systems Assessment of PFBC |
| AA5505050 | 00159 | Dist Heating Turbine Study |
| AA5515150 | 00011 | Low-Temperature Heat Utilization |
| AA7505100 | 00100 | Coal Preparation Plant Automation |
| AA7505150 | 00100 | Coal Preparation Plant Automation |
| AA8507000 | 00210 | IEA Tech Rep |
| AA8515050 | 00238 | Critical Component Tech. Assmt. |
| AA8515100 | 00810 | Matls & Comp Gasification |

[a]ORNL's base budget submittal, April 1982.

**Table A.3 (continued)**

| B&R Code | WPAS No. | WPAS Title |
|---|---|---|
| AA8515150 | 00232 | Slurry Pump Development |
| | 00233 | Hot Dirty Gas Heat Exchangers |
| | 00234 | Hot Dirty Gas Compressors/Expanders |
| | 00235 | Hot Dirty Gas Valves |
| | 00236 | Plant Component Support |
| | A0218 | Adv P.V. Fab Tech |
| | A0219 | Gasif Matls Surv Tests |
| | B0218 | Electroslag Casting |
| | C0218 | Heavy Sect Weld & Test |
| | E0218 | Nondestructive Test Ultrasonic |
| | E0219 | Gasif Matls Review |
| AA8525050 | 00001 | Synthetic Fuels Data Mgt-UMD |
| | 00203 | METC Modeling Support |
| | 00237 | Gasifiers in Industry |
| AA8530050 | 00078 | Coal Conversion Solid Waste |
| AC1510104 | 00087 | Ionex and Enhanced Oil Recovery |
| CG0107000 | 00001 | RA-Coal Production Goals |
| | 00002 | RA/BLM Wilderness Studies |
| CH0203000 | 00203 | METC Modeling Support |
| | Assistant Secretary for Nuclear Energy | |
| AE2010050 | 01322 | Space Flight Systems Hardware |
| AE2015100 | 01307 | Support for Energy Center Studies |
| | 01308 | NEC Atmospheric Effects (METER) |
| | 01311 | Assessment of Process Applications |
| | 01447F | Technical Support |
| | 01478 | District Heating Studies |
| AE2081050 | 00000 | Other Spec Matls Inv-Irid-Change |
| AF0515000 | 01311B | Small Reactor Eval - Utility |
| | 01447G | Tech Sup for NE Plans & Anal Div |
| | CFR1 | Breeder Reprocessing |
| AF1540101 | OH016 | Measurements & Controls Technology |
| AF1540102 | OH037 | Clad/Duct Development |
| AF1540103 | OR1.1 | High-Temp Structural Design Tech |
| | OR1.10 | MSTMC Development |
| | OR1.3 | Mech Props Design Data |
| | OR1.4 | Fabrication |
| | OR1.5 | NDT Technology |
| | OR1.7 | Advanced Alloy Development |
| | OR1.8 | Documentation |
| AF1540104 | OH004 | Fast Shielding Experimenal Prog |
| | OH013 | Cross Sections for Reactor Mtls |
| | OH015 | Radiation Shielding Info Center |
| | OH054 | Meth Dev, Sensit Anal-INT Exp Test |
| | OH057 | Shielding Analysis |
| | OH153 | US/UK Actinide Irradiations |
| AF1540105 | OH020 | R&D Integration |
| | OH044 | LOA-2 THORS |
| | OH136 | LOA-4 Environment |
| AF1540303 | 01447H | Tech Sup NE Plans Anals Div |
| AF1540352 | OH022 | Nuclear Standards Management Center |

**Table A.3 (continued)**

| B&R Code | WPAS No. | WPAS Title |
|---|---|---|
| AF1540836 | 00000 | Fuel Fab Inventory-TSF-Change |
| AG2520000 | 01329 | HTGR Chemistry Studies |
| | 01330 | Fueled Graphite Development |
| | 01331 | PCRV Development |
| | 01332 | HTR Materials Studies |
| | 01333 | HTGR Graphite Studies |
| | 01334 | HTR Shielding |
| | 01335 | HTR Physics |
| | 01336 | HTR Assessments |
| | 01337 | GA Irradiation Services |
| | 01338 | HTR CFTL Studies |
| AG3005000 | ORTMI01 | Dev. of Inorganic Sorbents |
| AG3620000 | 01311A | Small Reactor Eval.-Design & Cons. |
| | OH020A | Nuclear Safety Journal |
| AG4010100 | CFR3 | LWR Fuel Cycle Reprocessing |
| AG4015100 | CFR2 | Thorium Fuel Cycle Reprocessing |
| AH1005000 | ONLWF02 | FUSRAP Technical Support |
| | ONLWF03 | FUSRAP Information Support |
| AH1015000 | ONLWDX5 | Liners for Mill Tailings |
| AH1020000 | ONLWD06 | ILW Transfer Line Decommissioning |
| | ONLWD09 | Commercial Surplus Fac Surveil |
| | ONLWD17 | SFMP-Info Support |
| AJ0581000 | 00000 | Inventory Change-Hafnium |
| AP0515150 | ONLWI02 | Integrated Data Base |
| | ONW1130 | Institutional Arrangements |
| | ONW1300 | Reg Env Charac Studies |
| | ONW2803 | Eff of Water in Salt Repositories |
| | ONW2806 | Salt Model Pillar Studies |
| | ONW2807 | Expected Repository Environments |
| | ONW2812 | Evaluation of Avery Island Coupons |
| | ONW2814 | Flooding in Waste Repository |
| AP0515250 | ONLWR02 | Commercial Waste Transport Studies |
| AP0525050 | ONLWA02 | Krypton Hydrofracture |
| | ONLWA06 | Fusion Waste Management |
| AP0525100 | ONLWH02 | Fixation of Wastes in Concrete |
| | ONLWH10 | High-Level Waste Container Dev-ORNL |
| | ONLWH16 | ORNL Sol-Gel Coated Particles |
| AP0525150 | ONLWL03 | Waste Mgmt Info Sup |
| | ONLWL42 | State Screening Project |
| AP0525200 | ONLWT17 | FUETAP Concrete Immobilization |
| | ONLWT20 | Fuel Cycle TRU Waste Studies |
| AW0110030 | 00001 | AISP Gyrotron Development |
| CD1001228 | 01311C | Small Reac Eval-Multi-Unit |
| | 01447I | Tech Support for NE Plans and Analy |
| CD2001000 | ORN101 | GJOIS |
| | ORN102 | Recovery of Uranium from Phos Acid |
| Assistant Secretary for Conservation & Renewable Energy | | |
| AK0505000 | 00004 | High Voltage Research |
| AK0510000 | 00004 | Environ Eff of Dielectric Gases |
| | 00012 | HVTP |

**Table A.3 (continued)**

| B&R Code | WPAS No. | WPAS Title |
|---|---|---|
| AK0525000 | 00004 | High Voltage Research |
| | 00012 | High Voltage Technology |
| AK1005000 | 00014 | EES New Tech Integration |
| AK1010000 | 00007 | Electric Energy Use Mgmt |
| | 00011 | Athens Automation Experiment |
| AL0505050 | 00050 | Conservation & Renewable Studies |
| AL1005050 | 00001 | Thermal Energy Storage Program |
| | 00002 | Mechanical Energy Storage |
| AM0520000 | 00005 | Env Anal of Geoth Engy - Geopressur |
| AM1005100 | 00003 | Waste Heat Rejection-Geotherm |
| AM1505000 | 00004 | Env Anal of Geoth Energy - Hydro |
| CE1003000 | ONL017 | Envir Research for Small Hydro |
| EB0102000 | 00401 | Passive Cooling |
| | A2014 | BTESIM A2 Educ/Info |
| EB0103000 | 00017 | Eff of Wea & Atm Contam on PV |
| | 00018 | Decentralized Solar (DSETAP) |
| | 00021 | Tech Assist PV Demo Projects |
| EB0201000 | 00010 | Agri & Indust Proc Heat Sup |
| EB0202000 | 00000 | Funds Available Unassigned |
| EB0202010 | 00001 | Fuel & Chem From Woody Biomass |
| | 00002 | Effects of Whole Tree Harvesting |
| | 00012 | On-Farm Biomass |
| | 00026 | Asses-Poten Use of Biomass for Prod |
| | 00048 | FERT & Tilth Eff of Fuel Crop Res |
| EB0202021 | 00005 | Alcohol Fuels Biomass |
| EB0301000 | 00014 | EES-Wind Dynamics |
| | 00050 | Plan Anal & Eval of Conserv Prog |
| EB0302000 | 00013 | OTEC Power Cycles Development |
| EB1102000 | 00005 | Alcohol Fuels Biomass |
| EC0100000 | 00031 | BEPSII |
| | A1014 | Administration/Technical Support |
| | A2014 | BTESIM: A2 Research Utilization |
| | B0014 | BTESIM B Matl's |
| | C0014 | BTESIM C - Systems |
| | D0014 | D-Diagnostics |
| | E0014 | Innovative Concepts |
| EC0300000 | B0014 | BTESIM: B -- Materials |
| EC0400000 | 00006 | ANFLOW - Muncipal |
| | 00032 | Refuse/Energy Project |
| | C0014 | BTESIM C - Thermal Envelope System |
| EC0500000 | 00001 | Building Equipment Research |
| | A2014 | BTESIM: A2. Research Utilization |
| | D0014 | BTESIM D - Diagnostics |
| EC0600000 | 00020 | RCS-Tax Credit Analysis |
| | 00050 | Engineering Economic Models |
| | A2014 | BTESIM: A2 Research Utilization |
| EC0700000 | A0020 | Management of RCS Program |
| | B0020 | Management of RCS Program |
| | C0020 | Management of RCS Program |
| ED0101000 | 00009 | Materials - Waste Heat Utilization |
| ED0102000 | 00020 | ANFLOW - Industrial Wastewater Treat |
| ED0103000 | 00050 | Conservation and Solar Strategy |

**Table A.3 (continued)**

| B&R Code | WPAS No. | WPAS Title |
|---|---|---|
| ED0300000 | 00009 | Matls for Waste Heat Utilization |
| EE0101020 | 00002 | Toughened Cer for Adv Heat Engines |
| EE0104000 | 00001 | Ana of Trans Data Rel to En Use |
| EE0204000 | 00000 | Funds Available Unassigned |
| EE0503000 | 00001 | Anal of Transp Rel to Energy Use |
| EF0102000 | 00035 | Plan, Anal, & Eval of Conserv Prog. |
| EF0400000 | 00045 | Eval of the State Ener Conserv Prog |
| EF0500000 | 00045 | Eval of the State Ener Conserv Prog |
| EG0500000 | 00001 | ECUT Materials Project |
| EG0600000 | 00035 | ERIP Evaluation |
| | Office of Policy, Planning & Analysis | |
| PE0100000 | 00008 | Light Duty Vehicle Demand Model |
| | 00011 | International Policy Analysis |
| | 00034 | Cartel Models |
| | Office of Energy Research | |
| AT0520210 | 00046 | Tokamak Confinement Theory |
| AT0520230 | 00115 | EBT Confinement Theory |
| AT0520240 | 00047 | Theoretical Atomic Phy for Fusion |
| AT0530320 | 00048 | Controlled Fusion Atomic Data Ctr |
| | 00049 | Diagnostics of High Temp Plasmas |
| | 00050 | Atom Molec Nuc Physics in CTR |
| AT0540420 | 00052 | User Service Center Operations |
| AT101011G | 00002 | Tokamak Operations |
| AT101011Z | 00154 | Pellet Fueling-Confinement |
| AT102021C | 00008 | EBT-S Base |
| | 00127 | EBT-P Related Operations |
| | 00139 | EBT-S ICRH Installation |
| AT1510131 | 00011 | LCP Coil Subcontract |
| AT1510132 | 00013 | LCTF Construction |
| AT1510133 | 00122 | LCP R&D Activities |
| AT1510134 | 00012 | LCP ORNL Management |
| AT1510135 | 00014 | LCTF Operations |
| AT1510141 | 00056 | Advanced Conductor Development |
| AT1510142 | 00010 | 12 Tesla Coil Program |
| AT1520212 | 00017 | Adv Positive Ion Source Dev |
| AT1520214 | 00054 | Neutral Beam Test Fac Operations |
| AT1520221 | 00165 | RF Technology Plan Pro |
| AT1520222 | 00021 | Gyrotron Development |
| AT1520250 | 00023 | Pellet Fueling |
| AT1530310 | 00025 | Alloy Development for Irrad Perf |
| AT1530320 | 00027 | Plasma-Materials Interactions |
| AT1530330 | 00032 | Magnet Insulators and Stabilizers |
| AT1530340 | 00033 | Damage Analysis & Dosimetry |
| AT1530352 | 00034 | Radiation Facilities Operation |
| AT1540420 | 00164 | EBT Reactor Studies |
| AT1540430 | 00039 | RSIC |
| | 00041 | Blanket & Shield Int Exp |
| | 00160 | Data Eval & Process Fusion Neutronics |

**Table A.3 (continued)**

| B&R Code | WPAS No. | WPAS Title |
|---|---|---|
| AT1540450 | 00044 | Plasma Systems Analysis (Tokamak) |
| AT1550510 | 00043 | Magnetic Fusion Env Assess Prog |
| AT1581011 | 00000 | Fuel Fab Inventory-ORR-Change |
| AT1581020 | 00000 | Common Use Stores Inv-Change |
| AT1581030 | 00000 | Other Spec Matl Inv-Change |
| AT1581040 | 00000 | Collat Funds & Other Dep-Change |
| AT2510000 | 00035 | FEDC |
| HA0201010 | 000801 | Dosimetry for Human Exposures |
| HA0202010 | 000143 | Fission Neutrons & Gamma Rays |
| | 000146 | Dose Response Relation in Chem Carc |
| | 000190 | Radiation Immunology |
| | 001562 | Somatic Effects of Environment |
| | 002374 | Nucleic Acid Biochemistry |
| | 002589 | Carcinogen Activity in Human |
| | 003148 | Sol St RIA in Cocarcinogenesis |
| | 003346 | Chem Carcinogens & UV Radiation |
| | 003441 | H-Coal Bioassay |
| | 003551 | Interpretation of Cancer Tests |
| | 003552 | Radn Carc-Time Dose Relation |
| | 003553 | Tumorigenicity of Azaarenes |
| | 003767 | Radiation Risk Assessment |
| HA0202020 | 000173 | Mammalian Biochem Genetics |
| | 000174 | Mammalian Genetics |
| | 000181 | Mammalian Cytogenetics |
| | 000237 | Mammalian Cell Genetic Toxicology |
| | 000287 | Medical & Molecular Genetics |
| | 001569 | Comparative Mutagenesis |
| | 001570 | Mammalian Chem Mutagenesis |
| | 002527 | Genetic Effect of Plutonium |
| | 002591 | Mechs of Mamm Mutagenesis |
| | 003152 | Genetic Basis of Mutagenesis |
| | 003354 | Genetic Dissection of DNA Repair |
| | 003445 | H-Coal, Mammalian Cell |
| | 003555 | Freezing Mouse Mutants |
| | 003768 | Flow Cytometric Assays for Carc. |
| | 003769 | Eastern Oil Shale, Cell Screening |
| HA0202030 | 000159 | Biostatistics & Biomathematics |
| | 000183 | Mammalian Gametogenesis |
| | 001702 | Pollutants in Cardiovascular |
| | 002362 | Chemical Toxicology |
| | 002373 | Teratology Mechs and Prescreening |
| | 003770 | Pharmacokinetics and Dosimetry |
| | 003771 | Immunotoxicology |
| | 003772 | Mammalian Reproductive Toxicology |
| HA0203010 | 000604 | Fusion Tech: Aquatic Environ Effec |
| | 000608 | Transport, Fate, & Effs of Ener Eff |
| | 000681 | Envir Effs of Enrichment Facs |
| | 000690 | Actinides in the Environment |
| | 002382 | Fld Site Env Res Rel Coal Conv |
| | 002528 | Radionuc Srcs in Coastal Zone |
| | 003156 | Technetium in the Environment |
| | 003356 | Comp Env Tox Coal Liq Prod |
| | 003731 | Eastern Shale Environmental |

**Table A.3 (continued)**

| B&R Code | WPAS No. | WPAS Title |
|---|---|---|
| HA0203020 | 000609 | Ecological Processes in Aquatic Sys |
| | 001693 | Trans & Effs Coal Conv Effuents |
| | 002382 | Fld Site Env Res Rel Coal Conv |
| | 003546 | H Coal Environmental Project |
| | 003659 | Bioengineering Research |
| | 004081 | Assess of Gas from Coal Conv |
| HA0203030 | 000929 | National Environmental Research |
| | 002936 | Dev of Guidelines for Montr |
| | 003659 | Bioengineering Research |
| HA0204010 | 001710 | Chem Char Org Matl Re Coal Conv |
| | 001722 | Facility for Bioassay Chem Sup |
| | 003175 | Gasifiers in Industry-UMD |
| | 003469 | H-Coal: Pollutant Char. |
| HA0204020 | 001624 | Atmosphere-Canopy Interactions |
| | NOEW66 | Tritium Contamination |
| HA0204030 | 000714 | Health Physics Research Reactor |
| | 000717 | Medical Physics & Internal Dos |
| | 001606 | Dev-Auto Microfluor-Personnel Mon |
| | 001608 | Resonance Ionization Spectroscopy |
| | 001609 | Environ. & Personnel Monitoring |
| | 001707 | Dosimetry for New Energy Sys Poll |
| | 003754 | Tracer Chemistry |
| | 003763 | VUV Laser Investigations |
| HA0204040 | 000714 | Health Physics Research Reactor |
| | 000717 | Medical Physics & Internal Dos |
| | 000722 | Atomic & Molecular Physics |
| | 001478 | Studies-Phys Param-Health Protect |
| | 001602 | Ion Chem in the Atmosphere |
| | 001604 | Ion Formation & Clustering Phen |
| | 001605 | Surf Inter & Ion Part Accretion |
| | 001706 | Microdosim & Biol Modeling |
| | 001707 | Dosimetry for New Energy Sys Poll |
| HA0205010 | 001669 | Global Carbon Cycle & Climate |
| | 003160 | Bioclimatology of Energy Impacts |
| | 003457 | Elevated CO2 Effects on Terrest |
| | 003547 | Comparison of Soil Org Carbon |
| | 003732 | Dev. of Laser Detection System |
| | 003781 | Sensitivity Analysis of CO-2 |
| | 003782 | Carbon Source/Fate in River/Res |
| | 003939 | Carbon Dioxide Info Center |
| | NOEW70 | Carbon Cycle Management |
| HA0206000 | 003462 | Health/Env. Impacts H-Coal |
| HA0281000 | 00000 | Fuel Fab Cost Inv-HPRR-Change |
| HB0100000 | 000151 | Regulation of Hematopoiesis |
| | 000158 | Growth & Regeneration |
| | 000162 | Mechanism of Radiation Lethal |
| | 000164 | Bioprocessing for Energy Production |
| | 000165 | Nucleic Acids in Pathogenesis |
| | 000167 | Theoretical & Applied Cryobiol |
| | 000169 | Enzyme Regulation |
| | 000177 | Drosophila Cytology & Genetics |
| | 000178 | Yeast Mutagenesis |

**Table A.3 (continued)**

| B&R Code | WPAS No. | WPAS Title |
|---|---|---|
| | 000179 | Microbial Mutagenesis & Cell |
| | 000184 | Effects & Uses of Chromosomes |
| | 000233 | Protein Synthesis-Aberrant Control |
| | 000282 | Photophysics of Macromolecules |
| | 000283 | Environmental Insults to DNA |
| | 000284 | Chromosome Chemistry |
| | 000288 | Molecular Genetics |
| | 000607 | Dev of Ecological Systems |
| | 000611 | Deciduous Forest Ecosystems Program |
| | 000718 | Transport & Surface Physics |
| | 000719 | Chemical Physics Studies |
| | 000720 | Liquid & Submicron Physics |
| | 000721 | Physics of Solids & Macromolecules |
| | 001471 | X-Ray Diffraction |
| | 001472 | Protein Chemistry |
| | 001476 | Molecular Aspects of Radiation |
| | 001560 | Chem Effects on the Immune System |
| | 001603 | Physicochem Prop of Chem Pollutants |
| | 001610 | Energy Pathways in Irrad Gases |
| | 001699 | Gene Expression in Carcinogenesis |
| | 001701 | Carcinogen-Cell Genome Interact |
| | 002360 | Studies-Tumor Cell Immunology |
| | 002368 | Reg of Membrane Transport System |
| | 002371 | Metabolism of Aromatic Amino |
| | 003236 | Mechanisms of Damage & Repair |
| | 003464 | Tissue Culture Facility |
| HB0201000 | 000982 | 86-In Cyclotron Tech Support |
| | 001161 | Nuc Medicine & Biomed Technology |
| | 003765 | Radisotope Prod Tech Dev |
| HB0281011 | 00000 | Radioisotopes Inv-Change |
| HB0281012 | 00000 | Non-EM Stab Iso Inv-Change |
| KA0101000 | 00001 | High Energy Physics |
| | 00002 | High Energy Accel Shield Studies |
| KB0101000 | 00011 | Meson Physics |
| KB0201000 | 00012 | Heavy Ion Nuclear Research |
| KB0202000 | 00016 | Heavy Ion Laboratory Operations |
| | 00017 | HHIRF User Support |
| | 00018 | Heavy Ion Laboratory Development |
| KB0300000 | 00020 | Theoretical Nuclear Physics |
| KC0101010 | 00001 | Light Ion Nuclear Physics |
| | 00004 | Basic Neutron Physics Research |
| KC0101020 | 00005 | Operations - ORELA |
| | 00006 | Nucl Data-Fusion & Fission React |
| | 00008 | Neutron Capture |
| | 00010 | One-Atom Det-Sol Neut Meas |
| KC0101030 | 00002 | Nuclear Data Project |
| KC0102010 | 00013 | Electromag Isotope Separation |
| KC0102020 | 00014 | High Flux Isotope Reactor |
| | 00015 | Transuranium Element Processing |
| | 00016 | Dist of Special Isotopes for Res |
| KC0102030 | 00012 | Chem of Transuranium El & Comp |
| KC0201000 | 00128 | Cap Equip for Hi Temp Matls Prog |

**Table A.3 (continued)**

| B&R Code | WPAS No. | WPAS Title |
|---|---|---|
| KC0201010 | 00018 | Theoretical Studies of Metals and A |
| | 00019 | X-ray Research Using Synchro Source |
| | 00020 | Anal & High Voltage Electron Micros |
| KC0201020 | 00021 | Deform & Fract of Metals & Alloys |
| | 00026 | Mech Prop - Ceramics |
| KC0201030 | 00022 | Solid State Reacts & Phys Props |
| KC0201040 | 00023 | Radiation Effects |
| KC0201050 | 00024 | Fundamentals of Welding & Joining |
| | 00124 | Research in Ceramics Processing |
| KC0202010 | 00027 | Interatom Interact in Cond Systems |
| | 00028 | Prop-Defects, Supercond, Hydrides |
| | 00029 | Support for Neutron Users' Program |
| KC0202020 | 00031 | Phys Prop of Superconductors |
| | 00032 | Phytophys Proc-Solar Energy Conv |
| | 00033 | Fund Aspects of Metal Fracture |
| | 00038 | Scatter of Synchrotron Radiation |
| | 00134 | High Temp Ceramic Materials |
| | 00136 | Prep & Char of Res Matls |
| | 00137 | Small-Angle X-Ray Scattering |
| KC0202030 | 00039 | Theory of Condensed Matter |
| KC0202040 | 00040 | X-Ray Diffraction & Electron Micros |
| | 00044 | Gases in Metals |
| KC0202050 | 00017 | R&D - Isotope Research Matls Prep |
| | 00042 | Surface Physics & Catalysis |
| | 00142 | Support for Ion Beam and Laser User |
| | 00143 | Ion Beam Analysis & Ion Implant |
| | 00144 | Radioactive Waste Storage |
| KC0203010 | 00045 | Chem Structure of Energy Rel Mat |
| KC0203020 | 00046 | Thermodyn of Energy Related Syst |
| | 00047 | Chem Eng Res (Matls Science) |
| | 00048 | Hi Temp Chem & Thermo Str Mat |
| KC0203030 | 00051 | Local Corr & Str Cr Ph Rel En Tech |
| KC0281024 | 00000 | Fuel Fab Inventory-BSR-Change |
| KC0281025 | 00000 | Fuel Fab Inventory-HFIR-Change |
| KC0281030 | 00000 | OSM Inv-PA-231, TH-230-Change |
| KC0301020 | 00055 | Atomic & Molecular Coll Dynamics |
| | 00056 | Photo, Pyro & React Int by El Spin |
| | 00059 | Molecular Res El Spectroscopy |
| KC0301030 | 00060 | Collision of Low Energy Ions |
| | 00061 | Accelerator Atomic Physics |
| | 00063 | Theoretical Atomic Physics |
| | 00064 | En-Tandem Operations |
| KC0302010 | 00069 | Kinetics of Enzyme |
| | 00072 | Basic Aq Chem to Hi Temp & Press |
| | 00073 | Het Catal Related to Energy Systems |
| | 00074 | Org Chem & Chem Fossil Fuels |
| | 00075 | Molten Salt Cat Clean Fuel Synthesis |
| KC0302020 | 00068 | Fuel Cycle Chemistry |
| | 00076 | Research in Chem Engr Seprs |
| | 00077 | Tritium Separation Technology |
| | 00078 | Separations Science Research |
| | 00080 | Fund Concepts for Res Recovery |

**Table A.3 (continued)**

| B&R Code | WPAS No. | WPAS Title |
|---|---|---|
| | 00082 | Fund of Separations Chemistry |
| | 00084 | Flow Through Porous Bodies |
| | 00085 | Molten Salt Proc High Lev Rad Waste |
| | 00087 | RD&D Adv Chem Meas Tech |
| | 00088 | Mass Spec R&D for Inorg Act Anal |
| | 00089 | Res & Dev in Second Ion Mass Spect |
| | 00090 | Mass Spec R&D Org Analysis |
| | 00091 | Adv Spec Meth for Chem Anal |
| KC0302040 | 00189 | Sorption Pumping & Transfer Oper |
| KC0401000 | 00100 | Engineering Science Center |
| KC0402010 | 00105 | Computational Mathematics |
| | 00106 | Applied Analysis |
| KC0402020 | 00107 | Statistical Methods |
| KC0402040 | 00110 | Special Projects |
| KC0403020 | 00111 | Geochem of Crust Proc to Hi Temp & Press |
| KC0600000 | 00114 | Energy & Nutrient Utilization |
| KC0700000 | 00113 | Isotope Prod & Sales Distrib |
| KC0701000 | 01113 | Revenue on Isotope Prod & Sales |
| KD0100000 | 00001 | Technical Support for OER |
| | 00002 | Technical Support for ERAB |
| | 00003 | Environmental Analyses |
| KD0400000 | 00112 | Tech Development of Ordered Alloys |
| KE0103000 | 00007 | University Lab Cooperative Program |
| | Assistant Secretary for Defense Programs | |
| AR0505000 | ONLWD08 | Defense Surplus Fac Surveil |
| | ONLWD11 | Curium Facility Decommissioning |
| | ONLWD12 | Metal Recovery Bldg Decommissioning |
| | ONLWD16 | Disposition Planning |
| AR051005K | ONLWI01 | Integrated Data Base |
| | ONLWN01 | Liquid & Gaseous Waste Syst Oper |
| | ONLWN02 | ORNL Site Specific Low Level |
| | ONLWN03 | Gunite Tank Sludge Removal |
| | ONLWN04 | Solid Waste Storage Management |
| | ONLWN05 | Hydrofracture Mix Development |
| | ONLWN06 | Operational Planning & Development |
| | ONLWN07 | Volume Reduction Operations |
| | ONLWN10 | Mgmt Metal Waste-UCND Sites |
| | ONLWN13 | Central Waste Disposal Facility |
| AR0515050 | ONLWA05 | Carbon-14 Immobilization |
| | ONLWA08 | FTF Quality Assurance |
| AR0515150 | ONLWL01 | LL Waste Program Management |
| | ONLWL02 | Site Participation |
| | ONLWL09 | ORNL Remedial Action |
| | ONLWL14 | ORNL Disposal Site |
| | ONLWL25 | FRG Cooperative PRogram |
| | ONLWL32 | Shallow Land Burial-Handbook |
| | ONLWL33 | Remedial Action-Handbook |
| | ONLWL38 | Decontamination Effectiveness |
| AR0515200 | ONLWT02 | TRU Waste in Concrete |
| | ONLWT10 | Instrumentation Support |
| | ONLWT18 | TRU Waste Certification Program |

**Table A.3 (continued)**

| B&R Code | WPAS No. | WPAS Title |
|---|---|---|
| AR0515250 | ONLWB01 | Krypton-85 Light Developnment |
| | ONLWB04 | Low-Temp Heat Utilization |
| AR0525000 | ONLWR01 | Defense Waste Transport Studies |
| GB0381042 | 00000 | Inventory Change-Boron 10 |
| GC0102070 | OR00001 | Proliferation Information Workshop |
| GD0101000 | OR04011 | OSS Mass Spectrometry |
| GE0348040 | ON5419A | 233U Dispensing Facility |
| | ON5419B | Inventory--Heavy Element Production |
| | ON5519A | Con-Ed Conversion |
| GE0381044 | 00000 | SRM Inventory-Heavy Water-Change |
| GE0381054 | 00000 | Inv Change-Am-241, Np-237, U-234 |
| | | Assistant Secretary for Environmental Protection, Safety, & Emergency Preparedness |
| EF0700000 | 00001 | Office of Energy Contingency Plann |
| | 00023 | Energy Cont Plan Tech Supp |
| HA0101010 | 003474 | Envir Tech Assist and Guidelines |
| HA0103010 | 002975 | Occupational Risks |
| | 003921 | Equipment Support to Spain |
| HA0103020 | 002976 | Tech. Assess. Tapcut |
| HA0107010 | 800060 | Assess. of WWT for Coal Conv. |
| | 800361 | H-Coal: WWT PDU |
| | 800403 | Gasifiers in Industry-UMD-ECT |
| | 800441 | Treat. of Coal Conv. Biosludges |
| HA0107052 | 800477 | Radiological Surveys |
| HA0108010 | 600097 | Emergency Technology |
| HA0501000 | 003740 | Tech Assist to Spain |
| SA0101000 | 00023 | Tech. Assistance to OECP |
| UB0201000 | 00015 | Power Pooling Studies |
| | 00023 | Tech Assistance To OECP |
| UE0401000 | 00024 | Test Exer for Enrgy Cont Planning |
| | | Federal Energy Regulatory Commission |
| VI0104010 | 00002 | Wheeling |
| | | Economic Regulatory Administration |
| UA0100000 | 00008 | Fuel Conversion Environmental Prog |
| UB0101000 | 00015 | Power Pooling Studies |
| UC0101000 | 00020 | Regulatory Anal of Oil Refineries |
| | | Energy Information Adminstration |
| TA0100000 | 00001 | Anal in Support of Infor Valid Prog |
| TB0100000 | 00001 | Anal in Support of Infor Valid Prog |
| TB0300000 | 00001 | Anal in Support of Infor Valid Prog |
| TC0100000 | 00001 | Anal in Support of Infor Valid Prog |
| TC0300000 | 00001 | Anal in Support of Infor Valid Prog |
| TD0100000 | 00001 | Anal in Support of Infor Valid Prog |
| TD0300000 | 00001 | Anal in Support of Infor Valid Prog |
| TE2000000 | 00001 | Anal in Support of Infor Valid Prog |

**Table A.3 (continued)**

| B&R Code | WPAS No. | WPAS Title |
|---|---|---|
| Assistant Secretary for Management & Administration | | |
| LA0101000 | 00012 | Energy Data Base |
| | 00013 | Special Support Project |
| LA0102000 | 00010 | RECON Operations |
| | 00011 | RECON Development |
| | 00014 | Information Interchange Stds |
| | 00015 | RECON Revenue |
| | 00016 | RECON Users |
| | 00017 | Text Management System |

**Table A.4. Procurements and subcontracts**

Millions of dollars—BO

| | Fiscal year | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1982 | 1983[a] | 1984[a] | 1985[a] | 1986 | 1987 | 1988 |
| Subcontracts to other DOE laboratories | 0.6 | 1.0 | 1.0 | 1.1 | 1.1 | 1.1 | 1.1 |
| University subcontracts | 10.7 | 8.4 | 8.7 | 8.8 | 9.0 | 9.2 | 9.3 |
| All other subcontracts | 54.6 | 49.1 | 51.1 | 51.6 | 53.1 | 54.4 | 54.8 |
| Procurements | 26.1 | 25.1 | 26.1 | 26.3 | 27.1 | 27.7 | 27.9 |

[a]Escalation factors from FY 1982 to FY 1983 and from FY 1983 to FY 1984 are both 10%. Figures for FY 1985 through FY 1988 are in constant FY 1984 dollars.

**Table A.5. Phase of R&D analysis**

Millions of dollars—BO

| | FY 1982 | FY 1983 | FY 1984 |
|---|---|---|---|
| **Assistant Secretary for Fossil Energy** | | | |
| Basic Research | 0.9 | 1.0 | 1.1 |
| Applied Research | 5.2 | 5.3 | 7.5 |
| Exploratory Development | 1.8 | 1.9 | 1.8 |
| Advanced Development | 3.1 | 2.2 | 2.0 |
| Engineering Development | 2.8 | 1.8 | 3.3 |
| **Assistant Secretary for Nuclear Energy** | | | |
| Basic Research | 1.1 | 1.1 | 1.3 |
| Applied Research | 13.3 | 13.7 | 14.5 |
| Exploratory Development | 4.3 | 3.5 | 3.9 |
| Advanced Development | 7.7 | 6.4 | 7.4 |
| Engineering Development | 19.5 | 18.4 | 19.5 |
| Assistant Secretary for Conservation & Renewable Energy | | | |
| Applied Research | 1.7 | 1.4 | 1.0 |
| Exploratory Development | 11.0 | 12.5 | 9.6 |
| Advanced Development | 19.5 | 18.2 | 11.9 |
| Engineering Development | 0.9 | 0.7 | 0.4 |
| **Office of Policy, Planning & Analysis** | | | |
| Applied Research | 0.3 | 0.1 | 0.1 |
| **Office of Energy Research** | | | |
| Basic Research | 54.7 | 55.3 | 62.8 |
| Applied Research | 35.7 | 37.3 | 43.6 |
| Exploratory Development | 15.8 | 18.4 | 21.4 |
| Advanced Development | 17.5 | 20.4 | 23.8 |
| Engineering Development | 13.4 | 11.1 | 13.8 |
| Assistant Secretary for Environmental Protection, Safety, & Emergency Preparedness | | | |
| Applied Research | 6.7 | 4.6 | 4.1 |
| **Federal Energy Regulatory Commission** | | | |
| Applied Research | 0.0 | 0.5 | 0.5 |

**Table A.5 (continued)**

| | FY 1982 | FY 1983 | FY 1984 |
|---|---|---|---|
| **Economic Regulatory Administration** | | | |
| Applied Research | 0.4 | 0.2 | 0.0 |
| **Energy Information Adminstration** | | | |
| Applied Research | 7.2 | 9.8 | 9.0 |
| Assistant Secretary for Management & Administration | | | |
| Applied Research | 0.8 | 0.8 | 0.8 |
| Total | | | |
| Basic Research | 61.6 | 62.3 | 70.2 |
| Applied Research | 113.2 | 115.4 | 120.8 |
| Exploratory Development | 42.4 | 46.1 | 46.6 |
| Advanced Development | 59.3 | 59.1 | 56.5 |
| Engineering Development | 58.1 | 50.2 | 55.1 |

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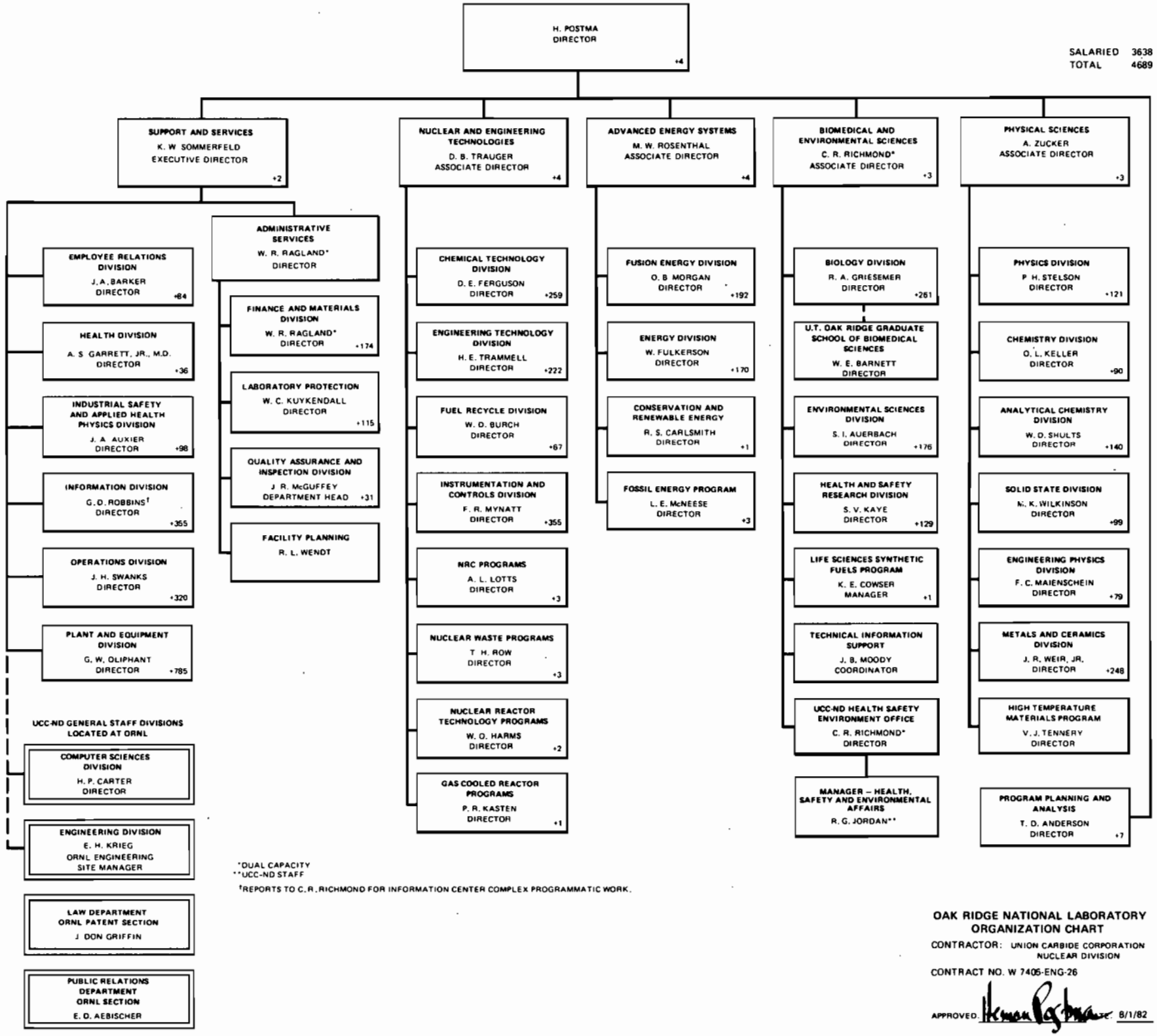


*DUAL CAPACITY
**UCC-ND STAFF
†REPORTS TO C. R. RICHMOND FOR INFORMATION CENTER COMPLEX PROGRAMMATIC WORK.

**OAK RIDGE NATIONAL LABORATORY ORGANIZATION CHART**

CONTRACTOR: UNION CARBIDE CORPORATION NUCLEAR DIVISION

CONTRACT NO. W 7405-ENG-26

APPROVED Herman Postma 8/1/82

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S. R. McNeany

Rec. No. 4325