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*Los Alamos National Laboratory  
Institutional Plan*

*FY 1985—FY 1990*

Los Alamos Los Alamos National Laboratory  
Los Alamos, New Mexico 87545

Part 3  
LR-16797

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Issued: November 1984

**Los Alamos National Laboratory  
Institutional Plan  
FY 1985—FY 1990**

**Los Alamos** Los Alamos National Laboratory  
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## **I. DIRECTOR'S STATEMENT**

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# I. DIRECTOR'S STATEMENT

As we enter the last half of the 80s, the Laboratory continues to strengthen its commitment to excellence in basic research and supporting technology development, an important ingredient to the increasing emphasis on improving national defense. In a changing and fractious world, I believe that the nation's best chance for continued peace comes from its lead in weapons technology. Los Alamos is helping to provide this superiority by designing both nuclear and non-nuclear weapons for the land, sea, and air-based elements of the defense triad. The Laboratory was recently assigned responsibility for design of two new systems, the stand-off antisubmarine warfare weapon and the Trident II warhead.

Defense programs remain the largest of our multifaceted activities and continue to grow, especially in our Strategic Defense work for the DOE and DoD. We are pursuing and emphasizing other important initiatives in defining energy options, basic research, and high-technology development. It is both an opportunity and a challenge to be at the forefront during this period when commitment to science and technology is critical to the nation's economic strength. Cooperation with industry, with universities, and providing technical assistance to other countries is a role that the government, through its multiprogram laboratories, can effectively fulfill.

During the period encompassed by this plan, we expect no radical changes in the general composition of Laboratory effort. Defense programs continue to account for about 60% of the total. We anticipate some small growth in energy programs, the combined result of very modest growth in several areas. Magnetic fusion programs, biomedical and environmental research, medium- and high-energy physics, and nuclear science and materials science will also experience some growth. If Los Alamos follows national trends, then Nuclear Programs and Conservation and Renewable Energy programs may decline during the next few years. Thus, we will undoubtedly see some changes in the mix of program activities, and we expect that the Laboratory could grow from its current strength of 7400 FTE at a rate of about 1% per year.

Some highlights of the past year's accomplishments and our future plans include:

- The Antares Laser Facility began operation during the past year. A major part of the inertial confinement fusion program, in which lasers deliver huge amounts of energy for heating micropellets of fuel to create a fusion reaction, Antares' primary emphasis is the evaluation of carbon dioxide lasers as the driving force, and it is producing energy in the 40-kilojoule range.
- Significant improvements have been made in Operational Security. The protective force has been increased and numerous physical upgrades accomplished, or are in progress.
- The new Strategic Defense Research program that was created to coordinate and strengthen the Laboratory's ongoing work in ballistic missile defense has made significant progress in evaluating research on neutral particle beams, free-electron lasers, electromagnetic rail guns, and warhead vulnerability.
- An important new initiative to make available significant "open" supercomputing capacity to the research needs of such disciplines as materials sciences, chemistry, biology, earth sciences, and nonlinear studies gives promise of faster and broader advances in those fields. At present, state-of-the-art supercomputing is largely limited to urgent weapons programs, but future equipment funding will make available supercomputers to a larger segment of the Laboratory.

## Los Alamos

- The Los Alamos Meson Physics Facility has been producing exciting physics for 15 years. LAMPF, the world's pre-eminent medium-energy research tool, has met or exceeded all of its goals, and the extent of its contributions to the advancement of nuclear science has been significant. We are developing a proposal for a major redesign of LAMPF that will assure our leadership in medium-energy physics to the end of the century. The completed project would increase the maximum energy to 45 GeV and the beam power by a factor of 5. This new experimental facility would use intense beams of pions, muons, kaons, neutrinos, and anti-nucleons to study many interactions that remain to be understood.
- Collaborative research between Los Alamos and universities is becoming increasingly important. The synergistic and symbiotic relationships that emerge from these interactions are important in the research process and to the development and uses of technology. Numerous instances of collaboration between the Laboratory and the University of California and other institutions have emerged from our ties to the Institute of Geophysics and Planetary Physics, from the Center for Materials Sciences, and the Center for Nonlinear Studies. A Center for Noninvasive Diagnostics was established last year on the University of New Mexico campus to utilize nuclear magnetic resonance imaging in the medical sciences. Two other specialized centers, the Plant Genetics Engineering Laboratory at New Mexico State University, and the Center for Explosives Technology at New Mexico Institute of Mining and Technology, were organized earlier. We expect to have considerable research interactions with all three of these New Mexico-based activities.
- As DOE's lead laboratory for development of nuclear materials control and accounting technology, we are assisting most DOE nuclear facilities in establishing advanced systems that will provide sensitive control and accounting for nuclear materials.

As we begin the second half of the 1980's, we are aware that a free society such as ours must be strong and alert. We are accountable to the people whose interests we serve, and we confidently look forward to the future challenges which this Institutional Plan describes.



Director

## **II. LABORATORY ROLE AND MISSION**

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## II. LABORATORY ROLE AND MISSION

### *ROLE*

The Los Alamos National Laboratory

- contributes multidisciplinary skills for solving national problems with particular emphasis on coupling the basic sciences and engineering disciplines with technological innovation;
- conducts basic and applied research and development in support of its mission;
- brings flexibility and continuity to long-term complex programs;
- has unique facilities and knowledge that constitute valuable resources for rapid response to urgent national needs;
- provides an interface between research carried out at universities and the applications-oriented needs of government and industry; and
- supplies the government and the public with informed and independent scientific opinion.

### *MISSION*

The primary mission of the Los Alamos National Laboratory is to be a national resource of scientific, technical, and engineering capabilities focused on execution of its primary national security mission. It undertakes those multidisciplinary fundamental and applied research and development (R&D) activities necessary to maintain a leading position in the broad range of scientific and technical fields required for this mission. It also maintains close interaction with scientific personnel in universities and industry.

A succinct summary of the Laboratory mission is:

- develop nuclear warheads for the nation's defense,
- develop new concepts for defending against nuclear attack,
- support nonnuclear defense programs,
- develop arms control technology,
- support national energy R&D programs, and
- advance our science and technology base to be able to respond to national R&D needs.

To fulfill its mission, it focuses its scientific and technical efforts on (1) research, development, and test (RD&T) activities associated with the nuclear design aspects of all phases of the nuclear weapon life cycle; (2) associated national security-related tasks, particularly in strategic defense technologies, gas laser inertial fusion, intelligence analysis, verification and control technology, molecular laser isotope separation (MLIS), nuclear materials safeguards and security, and development of advanced nuclear and nonnuclear weapon concepts; (3) advanced magnetic fusion concepts; (4) nuclear physics; (5) high- and medium-energy physics, particularly in studies employing the Los Alamos Meson Physics Facility (LAMPF); (6) heavy-ion fusion; (7) life sciences and environment; (8) basic energy sciences; (9) base technology for nuclear, fossil, renewable, and geothermal energy; (10) conservation; (11) materials science; (12) modern chemistry; (13) chemical analysis; (14) lasers and photochemistry; (15) technology for control or isolation of nuclear, toxic, or hazardous wastes; and (16) other energy research programs and support to the Department of Defense (DoD) and the Nuclear Regulatory Commission (NRC) and other federal agencies.

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### **III. INITIATIVES**

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### III. INITIATIVES

Program initiatives are discussed in the Scientific and Technical Programs section under the relevant program area. This section contains an important Laboratory initiative.

#### *OPEN (UNCLASSIFIED) SUPERCOMPUTING*

Historically, the Department of Energy (DOE) nuclear weapons program has acquired and used state-of-the-art supercomputers in the design of nuclear weapons for cost-effective use of time, critical resources, and people; for obtaining theoretical insights that are not otherwise available; and for obtaining information experimentally unavailable because of the environmental constraints imposed on testing. Because of the needs of the weapons program, our state-of-the-art supercomputers have typically been installed in the Secure partition of our network and their use largely dedicated to that program. Thus, the broader DOE R&D community encompassing materials science, chemistry, biology, theoretical physics, and so forth, has not had adequate access to state-of-the-art supercomputers.

In 1983, in an arrangement with the Defense Nuclear Agency (DNA), Los Alamos placed a Class VI computer in its Open partition. Demand for that resource far exceeds its capacity. Only half of its capacity is available to R&D not related to DNA. Users of this computer include the Laboratory's Energy Division, Theoretical Division, Earth and Space Sciences Division, Physics Division, Center for Nonlinear Studies (CNLS), and Center for Materials Science (CMS). The Energy Division conducts reactor safety studies. Our Centers for Nonlinear Studies and for Materials Science are intended to foster collaboration with Laboratory scientists and academia. Availability of state-of-the-art supercomputing is essential to these efforts. An "open" (or unclassified) supercomputing resource provides researchers with computing capability that is often 100 times faster than what they have had. Thus, work that would take weeks elsewhere can be done in a few days.

The addition of new supercomputing capability in our Open partition will be cost effective, both in the use of people and in the cost of computing. More exciting, and more important, will be the advances in knowledge that result. An increase in open supercomputing capacity at Los Alamos will create greater opportunities in a broader spectrum of programmatic R&D activities at the Laboratory than ever before. An open supercomputing capability will be a tremendous asset to the Laboratory as well as to other programs in the national interest.

To achieve these goals, we have submitted major equipment-funding plans that will enable the Laboratory to acquire the necessary supercomputers. The following table presents the open supercomputer acquisition plan as outlined in Laboratory budget submissions and as input to the DOE Automatic Data Processing (ADP) Long-Range Plan.

#### Open Supercomputer Acquisition Schedule

January 1985	Cray-1 (interim machine)
April 1987	Class VII computer
April 1989	Class VII computer

The Class VII computer that arrives in April 1987 will replace the January 1985 Cray-1. The April 1989 machine represents the second Class VII computer in the Open partition. A Class VII computer is defined as one having at least four times the computing capacity of a Cray-1.

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## IV. OVERVIEW OF LABORATORY ACTIVITIES

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## IV. OVERVIEW OF LABORATORY ACTIVITIES

The trends in Laboratory effort over this planning period are illustrated by Fig. IV-1. It shows that no radical changes are expected in the general composition of that effort. However, one percentage point on that curve corresponds to 48-50 direct FTEs, and about 73-75 total FTEs, so some of the changes in the smaller programs are a very significant portion of their effort.

Defense Programs will continue to receive the major part of our direct research effort. (Cf. Fig. IV-4.) They amount to slightly over 60% of the total throughout the planning period, when the ASDP work done under sponsorship of other DOE organizations is added in. Their personnel level is fairly constant. At the end of the period it is within about 2% of its values near the beginning.

We expect some growth in Energy Research programs, from their 16-17% of Laboratory totals early in the planning period, to approximately 19% in the outyears. This will be the combined result of very modest growth in several areas rather than the result of large growth in a single area. Some growth is expected in magnetic fusion programs, in biomedical and environmental research, in medium energy and high energy physics, and in nuclear science and materials science.

Nuclear Programs will decline slightly over the period. The modest growth foreseen in space and terrestrial applications appears inadequate to compensate for the reduction in the LMFBR base program.

Conservation and Renewable Energy programs will suffer an even greater decline, going from just over 2% of Laboratory effort to only 1%, primarily as a result of the phaseout of our geothermal program. This loss is not compensated for by the expected growth in energy storage systems.

Fossil Energy will remain small throughout this planning period, but we do hope to see some growth in this important enterprise over the period. Nuclear Waste Policy Act projects also meet important national needs. They are twice the size of the fossil program projects, though they remain a small fraction of the overall Laboratory effort. Their size is expected to decline slightly over the planning period.

While DOE-supported research receives most of the Laboratory's attention, about one-eighth of our effort is devoted to closely related non-DOE Work For Others (WFO). Our principal sponsor and client is the Department of Defense, which accounts for about 6.5% of the Laboratory's efforts and over half its WFO. NRC is the next most important sponsor. Its present support of about 2.6% of our total effort will decline to about 1.9% by the end of the period. Figure IV-5 shows the present WFO distribution in more detail.

The resources required to carry out these program efforts are shown in Fig. IV-2, and our distribution of effort between direct and indirect is shown in Fig. IV-3. The direct effort portion of Fig. IV-3 includes the FTE of direct recharge programs and construction. All other program trends and percentages cited here are based only on the immediately applicable scientific and technical effort.

In addition to having these expectations for ongoing programs, the Laboratory has a number of proposed initiatives that are discussed throughout this plan. Table IV-1 lists such initiatives and shows their possible level of effort in FTE.

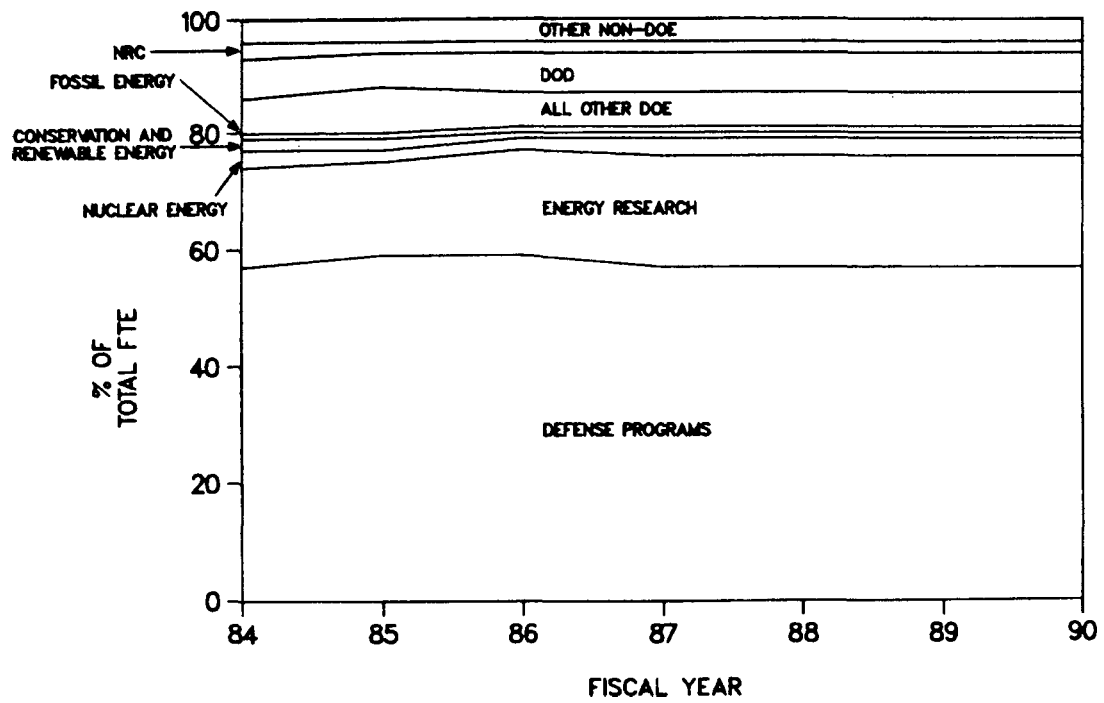


Fig. IV-1. Trends in Laboratory Effort

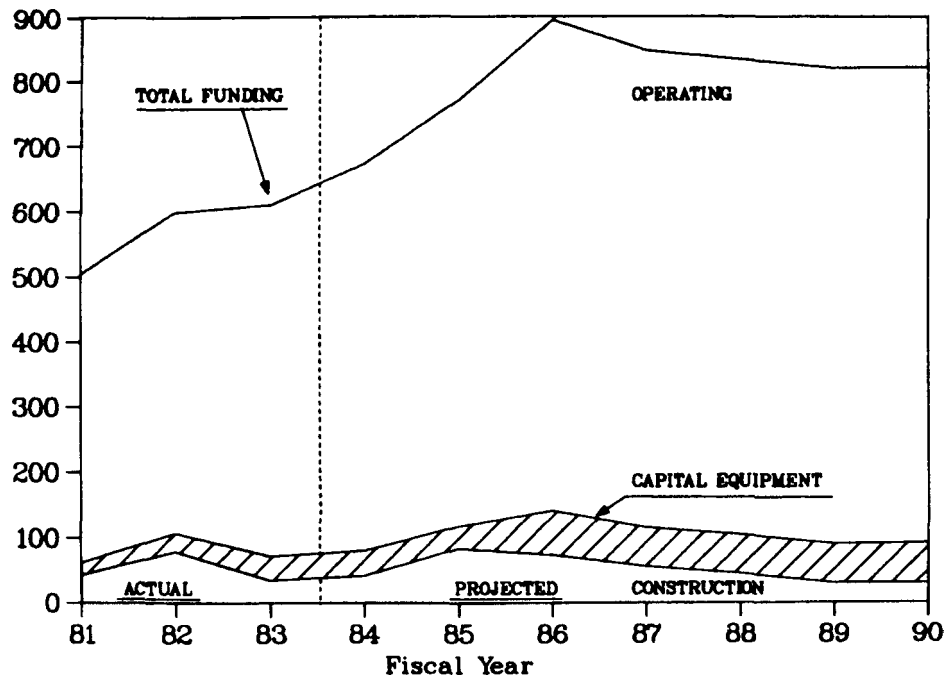


Fig. IV-2. Funding Level

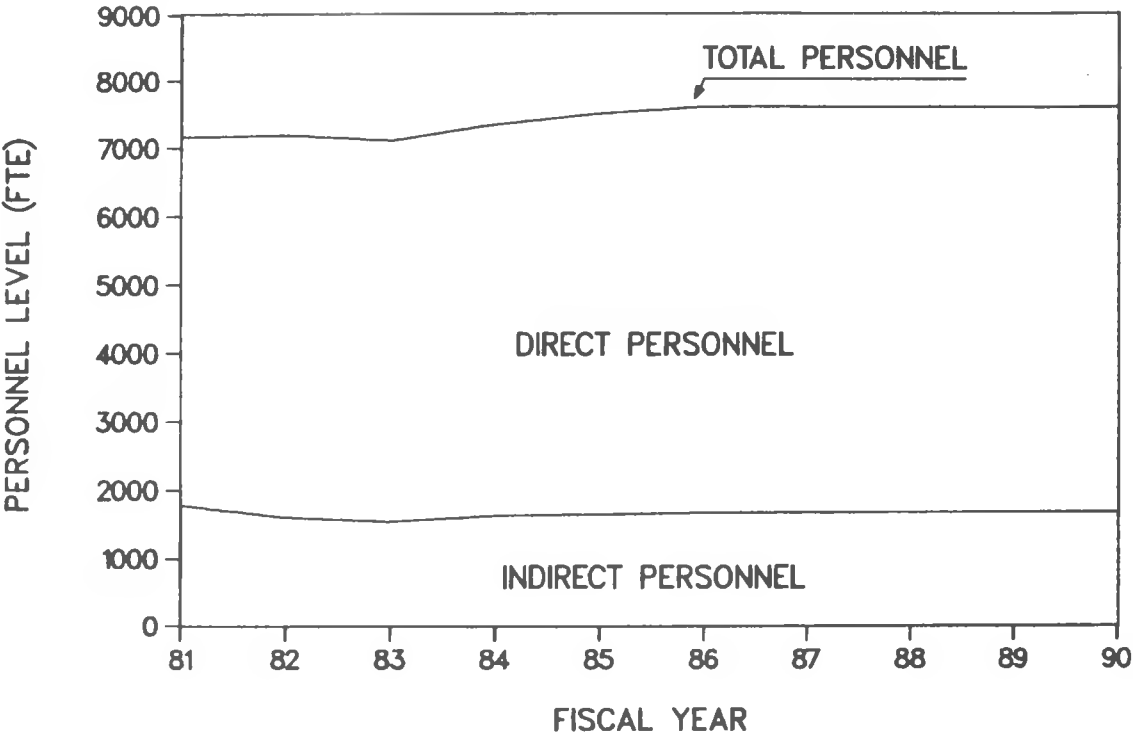


Fig. IV-3. Personnel Level

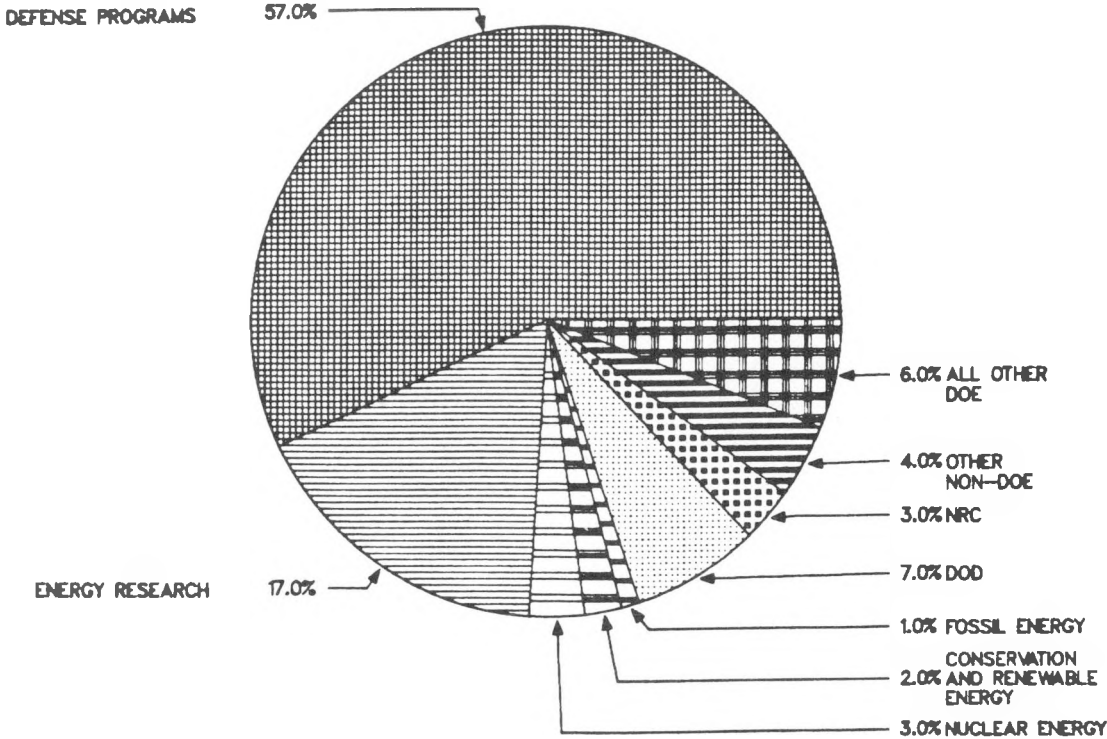


Fig. IV-4. Total Direct FTEs—1984

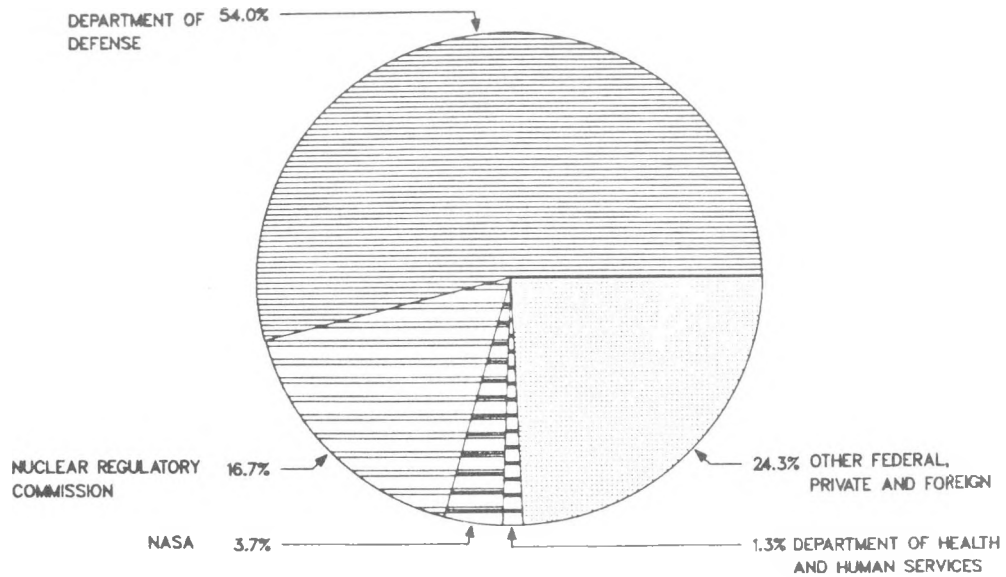


Fig. IV-5. Distribution of Work for Other than DOE (1984 Funding)

TABLE IV-1. Institutional Plan FY 1985-FY 1990  
Proposed Program Initiatives (FTE)

	FY 1984	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990
<b>DEFENSE PROGRAMS</b>							
<i>Military Energy Security</i>							
<b>ENERGY RESEARCH</b>							
National Underground Science Facility			5	10	13	13	13
LAMPF II Facility			30	140	140	140	140
ZT-H Experiment		8	18	23	30	20	
Motor Generator Set Facility		2	3	2	1		
Reversed Field Pinch (RFP)/ITR/ETR							
Radiobiology of Ultrasoft X Rays		5	5	5	5	5	5
Construc. & Application of a Protein Analyzer		7	7	5	4	4	4
Devel. of Topical NMR Meth. & Applications		1	2	2	2	2	1
Devel. of Coherent Vacuum Ultralight Source		5	3	3	3	3	3
Heavy-Ion Fusion Accelerator Research		12	18	18	18	18	18
<b>NUCLEAR ENERGY</b>							
Defense Terrestrial Reactor	2	6	6	6	6	6	
North Warning System	5	15	15				
Multimegawatt Program	3	15	18	25	25	25	25
<b>CONSERVATION AND RENEWABLE ENERGY</b>							
Electrochemistry and Catalysis		20	20	20	20	20	20
<b>FOSSIL ENERGY</b>							
Oil Shale	1	10	15	18	20	20	20
<b>INTERNATIONAL AFFAIRS &amp; ENERGY POLICY</b>							
<i>Caribbean Basin and Central America</i>							
<i>US/Mexico Cooperation</i>							
<b>DEPARTMENT OF DEFENSE</b>							
Free-Electron Laser (DARPA)							
Technology Demonstration Accelerator (US Army)							
Counterterrorism	8	12	20	28			
Block Funding for Nonnuclear Weapons		40	45	60	80		
<b>TOTAL</b>	19	158	230	365	367	276	249

## **V. SCIENTIFIC AND TECHNICAL PROGRAMS**

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## V. SCIENTIFIC AND TECHNICAL PROGRAMS

### DEPARTMENT OF ENERGY PROGRAMS

#### *DEFENSE PROGRAMS*

As sponsoring Secretarial Officer for Los Alamos, the Assistant Secretary for Defense Programs (ASDP) funds programs in weapons activities, verification and control technology, nuclear materials safeguards and security, materials production, and defense waste management. DOE laboratories and contractors reporting to the ASDP sponsor a small number of additional projects at Los Alamos. In FY 1984, these programs comprised approximately 61% of the total Laboratory budget. The weapons program in FY 1984 is divided into five categories as follows: weapons activities, 82%; materials production, 9%; verification and control technology, 4%; nuclear materials safeguards and security, 3%; and defense waste management, 2%.

Defense Programs have shown a modest but continuing increase in level of effort during the past 9 years. We expect this trend to continue and possibly accelerate somewhat if, as expected, nondefense programs activities decline and strategic defense increases.

B & R Code	Major Program	(\$ in Millions - BA)		
		FY 1984	FY 1985	FY 1986
AR	Defense Waste Management	6.7	7.1	10.3
GB	Weapons Activities	355.6	379.9	477.7
GC	Verification and Control Tech.	15.3	21.8	28.3
GD	Nuclear Materials Sfgds. & Sec.	12.0	22.1	26.6
GE	Materials Production	42.7	48.1	48.3
Total		432.3	479.0	591.2
	Percent of Laboratory Funding	63	65	61

## *Current Programs*

### *WEAPONS ACTIVITIES*

*Nuclear Weapons.* The primary goal of the Los Alamos nuclear weapons program is the development of state-of-the-art nuclear weapons that will continue to insure our national security commitments. Weapon requirements are determined through close interactions between the DoD, military services, their contractors, and the DOE Office of Military Application. Through the years, to meet these requirements we have developed warheads that are safer, smaller, more efficient, more reliable, and more survivable. Since 1979, all new strategic warheads that have entered the stockpile have been Los Alamos designs. These include the Trident I (W76), Minuteman III (W78), and the ALCM (Air-Launched Cruise Missile) (W80-1). We continue to provide designs for the B61 bomb, the SLCM (Surface-Launched Cruise Missile) (W80-0) warhead for the Navy Cruise Missile, the SM-2 (N) (W81) warhead for the Navy Standard Missile II, and the warhead for the Antisubmarine Warfare/Standoff Weapon (ASW/SOW). We are currently also working on conceptual and feasibility studies for several future nuclear weapons systems.

The budget allocation process at Los Alamos for the nuclear weapons RD&T program is designed to produce a weapons program aimed at responsiveness to programmatic needs rather than responsiveness to a fixed budget. The process involves structuring the program to enhance the balance in research, development, and weaponization activities so necessary in meeting our technical goals. Management of the program is structured to unite technical leadership and program management responsibilities. This approach was initiated 2 years ago and has resulted in continuity and an orderly development of projects within the nuclear weapons program.

The first of the major categories, Research Activities, includes a direct dollar contribution to the Laboratory's Institutional Supporting Research and Development. This effort is designed to maintain and enhance the technology base, to strengthen the scientific and engineering capability, and to promote interactions of the Laboratory research staff across all Laboratory programs. The National Security Program (NSP) Program Development component addresses important R&D needs and scientific tools required to prepare an initial basis for future programs.

Under Advanced Concepts, which constitutes about 17% of the total effort, there are three major program elements: New Sources, Advanced Design Technology, and Directed Energy. New Sources includes the study of thermonuclear burn, x-ray generation, and plasma-driving techniques. The Advanced Design Technology element focuses on improvements in traditional nuclear design that relate to future weapon requirements. The Directed Energy Concepts element looks to the future regarding offensive and defensive weapons-system concepts including conventional (nonnuclear) weapons and directed-energy technologies and applications that are conceptually different from traditional design practices. The Directed Energy element is expected to see increases in effort through FY 1984-1989.

The third major category, Technology Base, constitutes about 25% of the total effort and includes five major program elements: Computations, Advanced Weapons Engineering, Materials and Fabrication, High-Explosives (HE) Technology, and Weapons Physics. The Computation element develops the design codes required to incorporate our physics understanding into nuclear weapons design. Advanced Weapons Engineering provides the transition from theoretical design to weaponized design that includes subsystem design as well as materials and structural considerations. Materials and Fabrication provides the R&D effort in materials and processes to maintain state-of-the-art capabilities to address weapons materials and fabrication needs. The HE Technology element supplies the R&D related to developing explosives and using explosives in weapon systems. Weapons Physics consists of research to increase our understanding of physical processes in weapon designs.

The fourth major category, Weaponization, constitutes about 20% of the total effort and involves theoretical and engineering design of current and future weapons and management of the Los Alamos-developed portion of the stockpile. The weaponization and applications category involves weapons studies, current weapons development, new production, and evaluation and maintenance of the stockpile. Weapons studies include our efforts in the areas of conceptual and feasibility studies of future weapons. In the current Weapons Program element, we include the development of specific weapon systems, such as the development of the warheads for the new Trident II missile and the ASW/SOW.

Two additional major program elements are Test Operations, which constitutes about 28% of the total, and Special Projects, which constitutes about 4% of the total. Test Operations provides all field operations, including site preparation, device fabrication, containment, and diagnostic support for the Los Alamos nuclear test program. This element also provides for diagnostics R&D to support the Nevada Test Site (NTS) diagnostics effort. These efforts will increase as the number of NTS shots and the diagnostics requirements increase. The Special Projects element supports the Laboratory NSP mission with studies and capabilities that do not naturally fall in one of the other major program elements. Typical categories are Emergency Response, Facility Conceptual Design, and Radiation Litigation. These activities also allow the development of new activities in their formative phase and provide for short-term studies to support NSP.

Within this structure, we develop in-depth plans for the weapons program that specify directions, objectives and goals, anticipated time scales, resource requirements, and priority levels. This planning activity is performed from the bottom up and iterated back down through the performing organization in reaching the final plan.

*Inertial Confinement Fusion (ICF)*. The Los Alamos ICF Program is one of the main efforts by DOE to evaluate the scientific feasibility of inertially confined fusion using intense lasers or particle beams to compress and heat micropellets of deuterium-tritium fuel to fusion conditions. The primary goals of the national program are to support nuclear weapons physics research (near term) and to determine the feasibility of inertial fusion for energy applications, for example, commercial power generation (long term). An interim goal of tritium production by ICF for military and commercial uses is being evaluated for driver and target performance and cost effectiveness.

The Los Alamos program has four main efforts: (1) the evaluation of CO<sub>2</sub>-laser-driven ICF (CO<sub>2</sub>-ICF) by theory and experiments, (2) weapons research and experiments on unstable hydrodynamics for all ICF drivers, (3) R&D on advanced gas laser technology to provide low-cost options for future systems, and (4) the investigation of heavy-ion-driven inertial fusion. This broad program effort is warranted in light of the difficulty of the problem and the very large potential benefit to both the weapons and the peaceful applications programs.

The CO<sub>2</sub> laser is one of the most highly developed and possesses the necessary attributes of scalability, efficiency, reliability, and affordable costs for the long-term application. A substantial portion of the program resources have been used to bring this laser technology to maturity, and three high-energy, short-pulse, CO<sub>2</sub> fusion laser systems have been built and made operational for target physics experiments: Gemini (1976), Helios (1978), and Antares (1983). Thus, the determination of the feasibility and requirements for CO<sub>2</sub>-ICF is the current major effort at Los Alamos. With the CO<sub>2</sub> laser possessing all of the desirable attributes of a fusion driver for long-term applications, the technical challenge has been to invent a fusion target that achieves high gain when driven by the long-wavelength light of the CO<sub>2</sub> laser.

Experiments with the eight-beam Helios laser at the 5-kilojoule (kJ) energy level produced a wealth of laser/target interaction physics in the areas of absorption, laser energy conversion and transport, and plasma physics. The successful conclusion of this research program at Helios resulted in a sound understanding of the major aspects of CO<sub>2</sub> laser target physics at Helios energies. This laser was placed on standby in FY 1983 in anticipation of Antares operation.

The experimental emphasis now shifts to Antares with its added capabilities of seven to eight times more energy at the 30- to 40-kJ level. The data developed with Antares during the FY 1984 and FY 1985 experimental test series will be applied to the evaluation criteria for the FY 1985 decision milestone.

The long-term ICF goals will require a scalable, efficient, gas laser system with acceptable costs. We continue our R&D in advanced short-wavelength gas laser technology to ensure that options will be available at the time of the FY 1987 national program decision point on future directions. This program has two thrusts: the first is the study of ICF laser-technology base systems to provide the next energy level after Antares should it be needed following the FY 1985 decision.

Los Alamos has been given the lead laboratory assignment for the Heavy-Ion ICF Program. In collaboration with the Lawrence Berkeley Laboratory (LBL), a High-Temperature Experiment (HTE) has been planned that will provide an accelerator capable of driving a target to temperatures greater than 50 eV and that will address issues of particle accelerator technology, beam transport and focusing, and charged-particle interactions. The major portion of the work in the first years involves accelerator development that will be carried out at LBL. Los Alamos will concentrate on developing a high-brightness, high-voltage injector for moderate Z ions. Our current object is to complete a 16-beam injector of 2-MeV sodium ions in FY 1986. Funding for the Heavy Ion Fusion Accelerator Research (HIFAR) program is primarily from the DOE Office of Energy Research (OER) with approximately \$5.5 million in FY 1985.

The Los Alamos ICF Program provides overall management and supports heavy ion fusion in the additional areas of target design and system analysis. The target design task takes advantage of our existing theoretical capability to make a valuable contribution to the program in a cost effective manner. In systems analysis Los Alamos is responsible for a two-year long Heavy Ion Fusion System Assessment, funded jointly by the DOE OER and Office of Inertial Fusion (OIF), and the Electrical Power Research Institute (EPRI). Work on this study will be carried out primarily by Los Alamos and LBL, but will include participation by Lawrence Livermore Laboratory, industry, and universities.

In summary, the current ICF program includes R&D in the following areas: driver/target interaction physics; target implosion studies; theory and code development, including nuclear design codes and plasma physics codes; CO<sub>2</sub> laser target interaction experiments; target fabrication diagnostics development; advanced driver R&D; ICF systems studies; and weapons applications experiments.

## *VERIFICATION AND CONTROL TECHNOLOGY*

The goals of the verification and arms-control technology program are to provide technical, analytical, and other support to the DOE arms-control measures. These include foreign technology assessments, technology transfer issues, and detection of nuclear explosions underground, in the atmosphere, and in space.

*Nonseismic Nuclear Explosion Detection.* The ionospheric monitoring and infrasonic programs are directed toward verification of nuclear test ban treaties. The programs seek to detect and measure atmospheric and underground nuclear explosions by observing ionospheric and atmospheric signatures that result. As a longer-range goal, we hope to develop the capability to estimate yields from these data. With this effort, Los Alamos will provide technical guidance to DOE and other agencies to ensure that adequate verification provisions are included in negotiations.

*Satellite-Based Nuclear Explosion Detection.* Satellite-based test detection is a continuing Los Alamos program that began about 1960 with design and preparation of the first pair of Vela satellites, launched in 1963. Satellite-based test detection is continuing in multimission Air Force

satellite programs for which Los Alamos and Sandia National Laboratories (SNLA) jointly provide instrumentation for verification of compliance with the Limited Test Ban Treaty. In general, Los Alamos is responsible for instrumentation to detect the direct x-ray, gamma-ray, neutron, and charged-particle radiations from nuclear detonations in space; SNLA provides optical instrumentation for sensing atmospheric detonations and provides electronic logic for data handling.

In addition to providing surveillance of foreign nuclear explosions in space and in the atmosphere, this joint project supports DoD requirements for obtaining wartime information on tactical nuclear bursts. It also supplies data on natural and artificial space radiation. Finally, the project conducts R&D in related technologies, including those for potential detection of directed-energy weapon testing.

There is a recognized need to augment the deep-space and Southern Hemisphere detection capability. In the past, satellite deployment has emphasized and has been designed for detection of explosions relatively near the earth and in the Northern Hemisphere. Deep space may offer an attractive region for clandestine tests with yields larger than those allowed by the Threshold Test Ban Treaty; the September 22, 1979, event pointed out the need for improved surveillance of the Southern Hemisphere for verification of the Limited Test Ban and Nonproliferation Treaties. Achieving an effective deep-space detection capability will require both instrumentation development and deployment on either dedicated or multimission satellite systems in low-radiation-background orbits. Southern Hemisphere coverage will be enhanced when new satellite systems become operational in the next few years, but new diagnostic techniques and deployment scenarios are needed to provide independent corroborative evidence that otherwise ambiguous signals are of nuclear origin.

*Other Verification Research.* We are implementing research programs in innovative nuclear material and nuclear-explosion-detection techniques and yield-verification analysis.

## *NUCLEAR MATERIAL SAFEGUARDS AND SECURITY*

The Safeguards and Security R&D Program at Los Alamos is designed to address current, evolving, and future needs, primarily in the area of materials control and accounting (MC and A). Strong interfaces with physical protection, containment/surveillance, and nuclear facility operations are necessarily included, as are substantial activities in computer and operations security. The program activities range from development of individual measurement devices to the design of complete systems integrated with physical protection and process operations elements, from fundamental measurement physics through engineering of the hardware and software to implement those measurements. The applications of the program cover the DOE complex, the commercial nuclear industry, and the international community. Consequently, the program includes not only R&D efforts but applications in operating facilities. The program structure comprises four tasks and their subelements:

- Nuclear Facility Support
  - Direct Facility Support
  - Safeguards Technology Training
- Security Development and Support
  - Computer Security
  - Operations Security
- Technology Development
  - Equipment Development and Engineering
  - Methods Development and Demonstration
- International Support

The program is carried out in close cooperation with nuclear facility designers and operators and operational safeguards and security personnel. The intent is twofold: (1) to ensure effective application of the best available technology and (2) to direct the technology development to identified and emerging needs. Significant support will be provided to the new Special Recovery Line and Naval Reactor Fuel Manufacturing Facility at Savannah River, the Gas Centrifuge Enrichment Plant and the Gaseous Diffusion Plant at Portsmouth, the Y-12 Plant at Oak Ridge, and the PUREX facility in Richland.

## *MATERIALS PRODUCTION—SPECIAL ISOTOPE SEPARATION*

Since FY 1979, Los Alamos has been developing the MLIS process for the separation of plutonium isotopes. We have successfully established a broad technical data base for the process and are now focused on engineering scaleup of the process.

During FY 1984 to FY 1986, Los Alamos will construct a pilot facility to test the isotope separation process at the TA-55 plutonium facility. The facility, called SIS-III, will be constructed in existing plutonium-qualified space. A small process support building [General Plant Projects (GPP) funded] is being constructed to house the laser/optical system. The process support building is not a plutonium-qualified facility.

Following initial product rate demonstrations, SIS-III will be used to provide special plutonium isotopes for the Los Alamos weapons programs. During facility construction, key product rate milestones are scheduled for May 1985 and July 1986.

*Fuels.* The Laboratory's effort in metal production has three aspects: (1) to recover plutonium from nonspecification (NS) residues, (2) to convert the PuO<sub>2</sub> (from the recovery process) to metal, and (3) to conduct an R&D program and transfer technology to Rocky Flats. Also, the Laboratory has been tasked to process the fuel and fabricate and ship Milliwatt Generator Radioisotope heat sources.

*Supporting Services.* This effort will provide technical support to the Office of Nuclear Materials Production (ONMP) in two general areas:

- (1) provide independent safety reviews of the existing production reactors at Savannah River, Hanford, and other existing ONMP facilities on request, and
- (2) provide program requirements and technical support as well as independent technical evaluations to the New Production Reactor program. The primary activity in this area will be independent safety review activities.

## *DEFENSE WASTE MANAGEMENT*

Defense waste management programs at Los Alamos include (1) burial operations or storage of the Laboratory's radioactive waste and (2) R&D or technology development to improve techniques for storing or disposing of low-level and transuranic (TRU) waste. Included in the operations are efforts to compact low-level wastes, certify currently stored and newly generated TRU waste for eventual transfer to the Waste Isolation Pilot Plant (WIPP), and develop improved air filter test facilities.

The TRU waste program includes development of improved methods for assaying TRU waste and the development of systems techniques to schedule the eventual transfer of TRU wastes from DOE sites to WIPP. Within the low-level waste program, Los Alamos also has responsibility for conducting experiments to improve low-level defense waste disposal practices in arid environments.

## *Initiatives*

### *MILITARY ENERGY SECURITY*

The Laboratory is engaged in an effort to establish a focal point for military energy R&D at Los Alamos. The program will provide DOE with coordinated energy R&D to meet the needs defined by DoD. The process should be similar to the process the Laboratory and the Albuquerque Operations Office use in providing support for nuclear weapons. The Laboratory would provide a dedicated technical team tasked to ensure (1) that the best technical capabilities in DOE are applied to identified problem areas, (2) that the interactions of DOE laboratories with universities and industry are coherent, and (3) that the time between the identification of a DoD need and provision of DOE technical support for that need is drastically reduced.

## ENERGY RESEARCH

B & R Code	Major Program	(\$ in Millions - BA)		
		FY 1984	FY 1985	FY 1986
AT	Magnetic Fusion	20.9	19.9	29.5
HA	Environmental R&D	12.0	10.9	14.8
KA	High Energy Physics	0.7	0.4	4.2
KB	Nuclear Physics	43.5	49.2	58.1
KC	Basic Energy Sciences	14.8	13.0	20.8
KE	University Research Support	0.0	0.0	0.1
	Total	91.9	93.4	127.5
	Percent of Laboratory Funding	13	13	14

### Current Programs

#### BASIC ENERGY SCIENCES

Los Alamos conducts a comprehensive program of basic research to support applied work in national security and energy technology programs, to strengthen its multidisciplinary scientific base, and to expand possibilities and future options for the nation. Basic research is fundamental to the health of the Laboratory and crucial to our overall success.

*Nuclear Sciences.* Nuclear data continue to play a major role in improvements of nuclear fission energy technology and will play a major role in the engineering of practical nuclear fusion reactors of the future. The Laboratory has unique capabilities in the pulsed-neutron [Weapons Neutron Research/Proton Storage Ring (WNR/PSR)] facility and in its versatile Ion Beam Facility for satisfying these data needs. The program concentrates on studies of charged-particle cross sections required by the fusion program and on cross sections for gamma-ray production in neutron-nuclear processes.

Heavy-element chemistry programs address (1) heats and entropies of sublimation for the actinide elements, their compounds, and alloys; (2) valence stabilities of plutonium, americium, and curium in selected solids important to radioactive waste storage and to theory development for long-term valence stabilities in solids exposed to radiation; and (3) solubilities of plutonium and neptunium oxides and hydroxides in near-neutral aqueous solutions as a function of Eh and pH, important in assessing possible nuclide migration in natural ground waters.

As of FY 1984, a program in Heavy-Ion Fusion Accelerator Research was transferred to the Nuclear Sciences portion of the Basic Energy Sciences budget and will be managed by DOE's Office of High-Energy and Nuclear Physics. In collaboration with LBL, an HTE has been planned that will provide an accelerator capable of driving a target to temperatures greater than 50 eV and that will address issues of particle accelerator technology, beam transport and focusing, and charged-particle interactions. The major portion of the work in the first years involves accelerator development that will be carried out at LBL. Los Alamos will concentrate on developing a high-brightness, high-voltage injector for moderate Z ions. Our current objective is to complete a 16-beam injector of 2-MeV sodium ions in FY 1986.

*Materials Sciences.* Materials sciences activities at Los Alamos provide knowledge essential to national defense technologies and to development of materials required in advanced energy technologies and in strategic materials substitution. Relatively fundamental and long-term research efforts are categorized into three major areas: metallurgy and ceramics, materials chemistry, and solid-state physics. Ongoing projects in metallurgy and ceramics include structural ceramics,

study of materials under multiaxial deformation, self-irradiation damage of ceramic nuclear waste, and neutron scattering as a technique for determining the structural properties of materials. Materials chemistry constitutes studies of mechanisms of compound formation on surfaces and of selective modification of chemisorption properties. Solid-state physics work includes properties of materials under ultrahigh pressure and heat engines.

A major thrust in the Los Alamos solid-state physics research is the application of neutron-scattering techniques using the WNR Facility for a broad range of problems in condensed matter science. The PSR is scheduled to become operational in 1985. When full beam capability is achieved, it will be the world's most intense pulsed-neutron source for condensed matter studies by neutron-scattering techniques. A national user program has been established to provide the university, industrial, and national laboratory communities with the appropriate neutron-scattering spectrometers. Major improvements slated to benefit the materials science users' program have been submitted for funding consideration in the FY 1986 budget. These include new experimental halls for neutron scattering, an experiment support building, and improvements to the existing experimental area.

Other new capabilities for materials science studies under development include the high-energy Rutherford backscattering and ion microprobe capabilities that recently became operational at the Los Alamos Ion Beam Facility. These capabilities will greatly improve analytical methods for a variety of Laboratory energy and defense programs. Los Alamos is also instrumenting several beam lines at the National Synchrotron Light Source at Brookhaven, which will provide new capabilities that will be highly complementary to the Los Alamos WNR/PSR neutron-scattering program.

To further the study of materials science and technology, the Laboratory has created the CMS. The objectives of the CMS are to enhance the contributions of materials science and technology to the Laboratory's defense, energy, and scientific missions. The long-range plan is to locate the CMS in the new Materials Science Laboratory that is part of the Laboratory's FY 1986 construction request.

*Chemical Sciences.* Chemical sciences projects provide fundamental understanding in a broad range of topics. These include the formation and properties of complexes of helium and hydrogen isotopes, the chemistry of  $\text{SO}_2$  bonding to catalytic substrates, and computation of thermophysical properties of mixtures. A major initiative for tunable, vacuum ultraviolet/extreme ultraviolet (VUV/XUV) light sources is proposed elsewhere in this document.

*Engineering and Geosciences.* An important engineering research project is intended to develop the concept of thermionic integrated circuits (TIC) for instrumenting and providing electronic control systems in high-temperature and high-radiation environments. The program has emphasized developing fundamental device understanding, manufacturing techniques, and finally prototype circuitry. This program is aimed at completing the R&D of TIC technology and transferring the technology to industry for applications in hostile environments.

Geoscience research focuses on basic questions relevant to geothermal energy, fossil fuel energy, and radioactive waste disposal. The geophysics element of this research includes studies of rock physics, acoustic and electrical properties, and seismology. Geochemistry research comprises coal and peat maturation studies; experimental and computational investigations related to natural hydrothermal systems including mineralogy and aqueous geochemistry, geothermometry, and calorimetry; and trace element and isotopic investigations into magmatic differentiation. Thermal regimes studies include shallow drill hole investigations and field studies in the Jemez Mountains region of north-central New Mexico, all of which yield geophysical, geochemical, and geological information pertinent to Continental Scientific Drilling Program (CSDP) investigations of magma-hydrothermal systems. Space plasma physics deals with the structure and flow of plasma energy in the solar wind, magnetosphere, and ionosphere; with the electrodynamic aspects of the solar wind/magnetosphere interaction; and with the acceleration and loss of energetic electrons from the terrestrial magnetosphere. Thus, the space component of this research applies plasma

physics and magnetohydrodynamics to problems relating to fusion energy technology, solar-terrestrial environment variability, and future space-based energy technologies.

The CSDP proposes to probe the earth's continental crust in order to investigate (1) geothermal regimes, (2) ore-forming processes, (3) the phenomenon of earthquakes, and (4) the composition, structure, and temporal-spatial relationships of rocks of the continental crust. Los Alamos can make important contributions to this program because of our expertise in isotope and trace-element chemistry, drilling technology, solid-earth geophysics, and crustal processes. We propose to support the CSDP by drawing on our interdisciplinary capabilities to (1) investigate the framework, origin, and evolution of deep hydrothermal systems through development of new sampling and analytical techniques and (2) deploy an ad hoc team to characterize the large variety of hydrothermal systems selected for study by the CSDP.

*Advanced Energy Projects.* The basic unit of electric charge is one-third that of the electron. Negative fractionally charged particles are interesting because they could replace electrons in atoms, molecules, and solids, leading to superdense states of matter. A combined theoretical and experimental effort is under way to search for fractionally charged particles in a wide variety of materials to determine which materials are most abundant in fractionally charged particles and to enrich the fractional-charge content of sample materials.

Another advanced energy project, in the science of magnetic refrigeration, promises significantly greater efficiency for cooling in the temperature range of 4-300 K. The program involves the testing and selection of materials, the evaluation of innovative mechanical designs, and the construction of refrigerators of pilot-model size to demonstrate practical applications. Applications are in cryogenic methods for gas production, in liquid H<sub>2</sub> fuel for space-launch vehicles, and in heat control in satellite systems, and may eventually include air conditioning for large structures such as apartment complexes and industrial buildings.

Another development in the area of novel heat engines/refrigerators is the adaption of thermal acoustics principles to construct machines with the potential for both exceptionally high efficiency and substantial thermal power. Experiments employing helium gas as a working substance have demonstrated the feasibility of such devices and have defined the conditions for their operation as either heat engines or refrigerators. The objective of the work begun in FY 1984 under the auspices of Advanced Energy Projects is to provide the technology for a thermal acoustic engine using liquid sodium as a working material and heat from a (space-based) nuclear reactor as a source of thermal energy to produce electric power.

Efforts continue at Los Alamos to develop laboratory lasers for the x-ray and gamma-ray region using both atomic and nuclear processes. The most important applications appear to be in materials research and the study of biological systems, perhaps by angstrom-scale holography.

*Mathematical Research.* Numerical mathematical models at the heart of current energy research problems involve, in a fundamental way, the numerical solution of complicated systems of nonlinear partial differential equations. An important project in mathematics is to unify and simplify new solution algorithms for such systems. Recent developments emphasize adaptive mesh methods such as adaptive multigrid and front tracking to resolve subgrid scale structures of discontinuous solutions. We also are creating software to resolve large nonsymmetric, nonlinear algebraic systems arising from irregular meshes. In multidimensional computational fluid dynamics, this program has partially supported numerical methods development in a particle-fluid model for spray dynamics and a new free-Lagrangian computing technique. We are also documenting a general code for calculating transient aerodynamics flows.

Recent discoveries at Los Alamos in the fundamental mathematical properties of nonlinear transformations promise to improve understanding of the onset and development of turbulence. To emphasize studies of nonlinear systems and to develop closer connections with other workers in this important field, the CNLS has been established at the Laboratory. The CNLS uses its extensive external visitor program, coupled with internal collaboration from personnel within

existing technical divisions at Los Alamos, as the basis for its research efforts. Much of the external visitor program and the internal collaboration is coordinated with general research themes.

*Computing Support.* Calculations needed for nuclear safety, thermonuclear fusion, molecular modeling, weapons design, and so forth, require computers over 100 times faster than state-of-the-art supercomputers. One way to achieve such increases in speed is to set several computers to work in parallel on a common problem. Indications are that within the next 5 years supercomputer manufacturers will offer systems with up to 16 processors. Successful exploitation of their potential performance will require algorithms, software, and hardware that, when combined as a single system, achieve high average processor use and introduce little additional work relative to a single-processor implementation. These are the objectives of research in high-performance computing systems at Los Alamos.

Thus far our research has shown that (1) a broad spectrum of scientific computation is amenable to parallel formulation; (2) significant gains in speed can actually be achieved through parallel processing, at least in systems with a few processors; (3) new software tools will be needed for problem decomposition and debugging; (4) it may be possible to support parallel processing with a modest set of program control structures; and (5) only a small set of extensions may be required for programming languages.

These are positive results, and they reflect the impact and importance of having equipment available for experimentation. However, significant and difficult issues remain to be solved such as input/output (I/O), software tools, and secondary storage management. Also, as the number of processors increases within a system, research in new algorithms is likely to become particularly important.

*Biological Energy Research.* We have submitted three new proposals for funding. They are entitled "Nonlinear Energy Transport Mechanisms in Biological Polymers," "Nuclear Magnetic Resonance Studies of Cell Wall Synthesis and Salt Tolerance in Cereals," and "Isolation and Characterization of Metal Responsive Gene Promoters." These proposals describe important opportunities for unique Laboratory contributions in the area of biological energy research.

*Carbon Dioxide Research.* We propose as a new initiative an integrated program that will use the spectroscopic, atmospheric-sampling, and remote-sensing expertise of the Laboratory to measure and monitor radiatively important gases (carbon dioxide and minor trace gases) in the atmosphere. These are activities for which Los Alamos is uniquely qualified. Unfortunately, this initiative is not of current programmatic interest. We will continue to explore areas of possible mutual interest with the Carbon Dioxide Research Division.

## *NUCLEAR AND HIGH-ENERGY PHYSICS*

*Nuclear Physics.* The Los Alamos role as the principal laboratory in medium-energy physics is fulfilled by the operation and development of LAMPF and Los Alamos participation in the research programs using LAMPF. This, the world's largest and most sophisticated nuclear science facility, provides unique accelerator-generated beams of protons, pions, muons, neutrons, and neutrinos to carry out a research program that includes fundamental studies of weak interactions and conservation laws, nuclear structure studies, nucleon/nucleon and pion/nucleon interactions, mesonic x rays, condensed matter physics, atomic physics, and nuclear chemistry. Applications-oriented programs in progress include radioisotope production, radiobiology studies, investigations of radiation effects in materials, and national defense-related studies.

Recent research highlights at LAMPF include measurement of double-isobaric analogue states in heavy nuclei; observation of about 65 neutrino-electron scattering events; finding new bounds for parity nonconserving p-p scattering; excitation of giant resonances by pions and protons;

catalysis of D-T fusion by muons; inelastic scattering of protons in medium-weight nuclei; production of exotic nuclei far from the valley of stability by pion double-charge-exchange reactions; and possible evidence for significant relativistic effects in proton-nucleus scattering at surprisingly low energies.

Nuclear chemistry research at LAMPF has two major areas of emphasis: pion-nucleus reaction studies and direct mass measurements of nuclei far from  $\beta$ -stability. The pion program uses activation and on-line counter and spectrometer techniques to study pion single and double charge exchange, pion production and absorption, and nucleon removal reactions in nuclei. These studies are designed to provide tests of current theoretical models for pion-nucleus dynamics, nuclear structure, and quark degrees of freedom in nuclei. In the area of direct mass measurements, an active research program is under way to systematically investigate and determine the masses of all nuclei in the light-mass, neutron-rich region up to  $A = 70$  as produced in 800-MeV proton-induced uranium fragmentation reactions. This undertaking will be facilitated by the novel Time-Of-Flight Isochronous (TOFI) spectrometer now under construction. Feasibility studies for a helium-jet-coupled on-line mass separator system indicate that such a system would substantially expand the present worldwide capabilities for studies of nuclei far from stability. This prospective facility, which complements the capabilities of the TOFI system, would enable mass and spectroscopic measurements to be made on several hundred as yet undiscovered nuclei of mass  $A > 70$ .

We maintain a very active medium-energy theory group and also involve eminent theoreticians from the academic community. This program provides support for the LAMPF experimental program and seeks to interpret the experimental results from research here and from other laboratories. This program includes research into strong-interaction amplitudes, reaction theory, nuclear structure, electromagnetic interactions with nuclei, weak interactions, hadron structure and decay, and manifestations of unified theories at low and medium energies. Effort is divided between fundamental theoretical developments and phenomenological analyses. The latter requires close ties between the theorists and the experimentalists working in Medium Energy Physics Division, in Physics Division, and at experimental facilities in this country and abroad; special emphasis is directed at understanding those experiments performed at LAMPF.

Pulsed neutrons for nuclear research are available from LAMPF at the WNR facility, and this capability will be enhanced when the PSR is completed. Neutrino physics at Los Alamos is receiving increasing attention with the development of a new facility that shares beam from Line D at LAMPF. Construction is nearly complete on a new station that can accept 20  $\mu$ A of LAMPF beam for study of neutrino oscillations and measurement of total reaction cross sections. Detector development is essentially complete and results are expected by the close of FY 1985. The experiment is located so that it could eventually accept beam from PSR, which will be fully operational in FY 1986. The neutrino production target facilities could be upgraded to accept at least 200  $\mu$ A of beam. With the planned addition of a "focusing horn," the neutrino intensity would then increase by a factor of 100 beyond that available for the oscillation experiment. Other future plans at LAMPF include installing and commissioning a good-resolution, low-energy spectrometer for inelastic pion-scattering experiments and increasing polarized target capability, making available a high-intensity polarized ion source leading to improved facilities for nucleon-nucleon experiments.

The present LAMPF Users Group consists of nearly 1,000 US and foreign scientists representing some 200 universities and laboratories and 10 industrial organizations. About 100 Ph.D. theses have been completed and about 190 postdoctoral scientists have received training and experience at the facility. Some 370 experiments have been considered completed, and about 1,000 papers reporting scientific results have been published in refereed journals. The report of a recent review panel chartered by DOE to assess major US nuclear science states "because of its size, the diversity of its science program, and its large user community, LAMPF is clearly the flagship of American nuclear science." LAMPF will continue to serve very fruitfully our national interests for the next 5

to 10 years. If it is to continue in the flagship role, major new capabilities will need to be added that permit addressing quark and gluon degrees of freedom in addition to pion, nucleon, and delta degrees of freedom. This initiative, labeled LAMPF II, is described elsewhere in the Institutional Plan.

In the Racetrack Microtron project, the Laboratory, in collaboration with the National Bureau of Standards (NBS), is developing the required accelerating structure that will be used to determine the feasibility of a National Electron Accelerator. A major component, the chopper/buncher system, has been delivered as a turnkey system for installation on the NBS injector line. Additionally, a National Center for accelerator design codes is being developed at Los Alamos.

The Laboratory also conducts intensive programs in medium-energy physics at other laboratories that offer capabilities complementary to those at LAMPF. These experiments address forefront physics objectives, the development of new experimental methods, and prospects for future development of the LAMPF facility. They include studies with the antiproton beam of the LEAR facility at CERN, development of a method to measure the production rate of technetium by solar neutrinos in molybdenum ore, and studies of the fission process by means of heavy-ion reactions.

*High-Energy Physics.* Pioneering research in high-energy physics at Los Alamos serves to broaden the scientific theoretical base and to develop new mathematical techniques for studying nonlinear phenomena that have applications in material sciences, fluid dynamics, and laser physics. The research emphasizes understanding models that unify strong, electromagnetic, weak, and gravitational forces; understanding the confinement of quarks; understanding the dynamics and symmetries of various field theories; application of elementary particle theory to cosmology and astrophysics; and understanding a nonconventional ultrahigh acceleration gradient principle at conditions similar to realistic accelerator operating conditions. Progress was made in several areas including supersymmetry, supergravity, and dimensional reduction; general field theory; strong interactions; and quantum theory. Techniques originating in particle physics have been applied to the solution of other problems. For example, the recent breakthrough concerning the onset of chaos was based, in part, on a thorough understanding of renormalization group techniques. We have also contributed to LAMPF particle physics activities, the LAMPF II concept, and Superconducting Super-Collider (SSC) considerations.

## MAGNETIC FUSION

The ultimate objective of the national Magnetic Fusion Energy (MFE) program is to provide the nation with an economical and environmentally acceptable source of energy that uses a nearly inexhaustible fuel supply. Los Alamos' position in the MFE program is characterized by its generic support activities [for example, the Tritium System Test Assembly (TSTA), insulator materials, nucleonics, and reactor systems studies] and by the unique role it plays in developing magnetic confinement advanced concepts that are more compact in nature. The objective is to develop higher power density approaches that offer a possibility for reducing development costs and the capital cost of future commercial machines, and that offer in other ways (by reducing risk and the time required to obtain neutron damage information) an improved fusion reactor end product. To implement this task will require an increase of efforts to explore the possibilities of compact fusion [Reversed Field Pinch (RFP), Compact Toroid (CT), Ohmically Heated Toroidal Experiment (OHTE), and so forth]. This should involve experimental and theoretical confinement studies and supporting development and technology in the areas of first wall, blankets, resistive magnetics, copper alloys, radiation-resistant insulators, and reactor systems studies.

A substantial part of the Los Alamos program is devoted to the development of two such advanced fusion concepts, the RFP and the CT. These systems derive their qualitative superiority from potential compactness and use of higher power densities that approach those of fission reactors.

The theoretical and computational group provides analytical and numerical support for the MFE program that complements the experimental work. Plasma equilibrium and stability are studied with MHD, Vlasov, and hybrid particle simulation codes as required by the physical conditions of a particular experiment. A diagnostic-development group also supports MFE experiments both at Los Alamos and at other fusion research centers across the nation.

Los Alamos also makes a significant contribution to the national effort in magnetic fusion technology with its work in the areas of tritium handling, neutronics, insulators and ceramics, reactor system studies, and engineering support for the Tokamak Fusion Core Experiment (TFCX) and the Fusion Engineering Design Center (FEDC) at Oak Ridge National Laboratory (ORNL). The Laboratory expects to fulfill an increasingly important role in developing the needed technologies for compact high-power-density systems.

*Reversed Field Pinch Program.* The RFP is an inherently compact toroidal, magnetically confined plasma system that has the potential to ohmically heat to ignition, achieve stable plasma behavior at the high-plasma-pressure to magnetic-pressure ( $\beta$ ) ratios required for economic reactor operation, and reduce reactor complexity. The ZT-40 RFP experiment's performance has considerably exceeded original goals, yielding plasma temperatures up to 400 eV, discharge durations as long as 27 ms, and plasma densities as large as  $10^{14} \text{ cm}^{-3}$ . It has demonstrated self-sustainment of the RFP configuration. Also, plasma parameters have been found to scale favorably with current, indicating a possibility that reactor design requirements will be satisfied. To exploit the experimental successes from the ZT-40, a larger experiment, ZT-H, is needed to address the reactor-relevant issues of plasma-confinement scaling, high-current-density operation, and high-power first-wall loads.

*Compact Toroid Program.* A CT is a toroidal plasma configuration in which the major confining fields are created by currents in the plasma rather than by currents in external conductors. In the Los Alamos CT program, both the field reversed configuration (FRC) (confined primarily by poloidal field) and the spheromak (having both poloidal and toroidal fields) are being investigated; they have achieved their initial physics goals by producing toroidal configurations with substantial lifetimes that are primarily confined by self-generated magnetic fields. The CTX experiment produces hot (140-eV) spheromak plasmas lasting 1-2 ms, a world's record thus far. Sustainment experiments have demonstrated that currents from external electrodes extend the spheromak configuration lifetimes to more than 6 ms; these results may lead to steady-state spheromak operation that would greatly simplify reactor designs.

A second type of CT, the FRC, is being studied in the FRX-C experiment. Experiments on this relatively small, inexpensive device have demonstrated impressive confinement, up to  $n_e 4 \times 10^{11} \text{ cm}^{-3}\text{s}$ , with ion temperatures in the 0.1- to 0.5-keV range. Modifications of the FRX-C experiment in 1983 have resulted in the demonstration that FRCs can be translated along a guide magnetic field out of the formation chamber into an external chamber that can be tailored for specific purposes such as improved confinement or efficient heating. Ultimately this unique capability for translation may allow qualitatively different fusion reactor designs in which the plasma formation and heating are spatially separated from the fusion burn; the plasma releases an intense flux of neutrons into a surrounding blanket that converts the neutron energy into thermal energy. Techniques for producing FRCs on a slow time scale characteristic of desirable reactor operation have been proposed.

and coordinated with the Princeton Plasma Physics Laboratory for the TFCX. The program also maintains a high-voltage, high-current test facility for the development and testing of interrupters as switching systems for superconducting poloidal and toroidal field coil systems.

*Tritium Systems Test Assembly Program.* The TSTA will integrate and demonstrate all technologies related to the deuterium-tritium fuel cycle for fusion reactor systems. System check-out and preliminary testing of TSTA with hydrogen and deuterium is under way. The Preoperational Appraisal of the TSTA was conducted by the Albuquerque Operations Office of DOE in April 1984. The first large-scale test with tritium was completed in June 1984. Fully integrated operation of the TSTA is scheduled for late 1986.

*Fusion Reactor Organic Insulators and Ceramics Programs.* The organic insulators project is assessing neutron irradiation damage to polymeric insulators for superconducting magnetic coils. Ceramics are evaluated for use in lightly shielded coils, as dielectrics for rf heating systems, and for structural applications. Design information is supplied for the TFCX, and materials development techniques are directed toward optimization of candidate materials.

*Reactor Systems Studies Program.* This effort evaluates the reactor potential of various alternative fusion confinement concepts. The broad nature of this task requires extensive, multidisciplinary interaction with groups inside and outside the Laboratory. These reactor studies are extremely useful in guiding research in alternative approaches to fusion. Recent studies have concentrated on identifying compact, high-power-density options for fusion power production in search of more attractive commercial end products.

*Blanket and Shield Engineering—Nucleonics.* This project develops nucleonic transport codes and calculates transport and distribution in space and energy of neutrons and gamma rays produced by nuclear reactions in complicated material systems such as fusion reactors. The resulting parameters, such as temperature distributions, induced radioactivity of components, biological radiation hazards, radiation damage to components, rate of tritium breeding, and so forth, are used to design blanket and shield arrangements for fusion reactors. In addition, nuclear data evaluation and multigroup processing support is provided to the US fusion nucleonics community.

*Fusion Materials Irradiation Test Project.* This project is in collaboration with the Hanford Engineering Development Laboratory. The Office of Fusion Energy (OFE) is currently seeking international cosponsorship with Japan and Europe. Los Alamos is designing and developing the 35-MeV, 100-mA cw linear accelerator for the facility. The first 5-MeV section of the accelerator is under construction at Los Alamos. In May 1983, the first accelerated beam was achieved through 2 MeV with the fully engineered cw ion source and an 80-MHz rf quadrupole accelerator. In April 1984, cw operation, with no beam, was achieved at full rf power. Recent negotiations indicate that the full international collaboration needed to proceed with FMIT construction is not likely in the near term. Therefore, the scope of the accelerator testing will be established to provide only the critical confirmation of accelerator feasibility.

## HEALTH AND ENVIRONMENTAL RESEARCH

Biological and environmental research at Los Alamos is focused on the effects of defense and energy technologies on our health and environment; it comprises fundamental studies in human health effects, animal and cellular toxicology, genetics, flow cytometry, environmental studies, and atmospheric sciences. Our program in nuclear medicine consists of R&D of new applications of radiation and of stable and radioactive isotopes for the diagnosis and treatment of human disease.

*Human Health Research.* Long-term health effects that may develop as a result of radioactivity from plutonium depositions in man are being studied. Mortality rates, the causes of

death, and the incidence of disease, especially cancer, for plutonium-exposed workers and nonexposed workers at six major DOE facilities are being ascertained for statistical analyses. Measurements of plutonium and other radionuclides are made on post-mortem tissues of workers and members of the general public to learn more about internal dose estimation models, excretion rates, retention or transfer between different human organs, and plutonium fallout exposure estimates.

*Health Effects Research in Biological Systems.* The multidisciplinary hydrocarbon and nuclear energy toxicology program will continue at Los Alamos. The ability to perform fundamental studies on bioactivity as related to fuel-processing modes will be expanded by the further use of bench retorts. Basic studies in cellular immunology and cell sorting will be used as techniques for analyzing the toxic effects of energy production.

Programs in life sciences research study the basic mechanisms of carcinogenesis, develop and validate systems for determining carcinogenic activity, and apply the system in the context of integrated programs designed to define the hazards posed by nuclear and oil shale technologies. Our basic and applied studies in regulation of gene expression and structure, genetic protective mechanisms, chromosome structure and function, chromosome damage assessment, heterogeneity of tumor cells, and the molecular basis of cell growth provide a unique combination of capabilities for exploring basic questions in carcinogenesis. They enable us to determine the roles of mobile genetic elements, chromosome alterations, mutations, gene amplification, and DNA methylation in the transformation of normal cells to malignancy. The combination of flow cytometry, molecular genetics, and somatic cell genetics is especially useful in exploring the relationship of aneuploidy to cancer. At present, the sorting of chromosomes with specific cancer-associated aberrations is being followed by cloning and isolation of the affected genes.

A collaborative project has been initiated with investigators from Lawrence Livermore National Laboratory (LLNL) to create recombinant DNA libraries from each of the human chromosomes. Sufficient amounts of DNA have been obtained from sorted chromosomes to permit the construction of libraries from chromosomes 13, 16, 17, and 22. Recombinant DNA techniques have been developed for cloning the small amounts of DNA available from flow-sorted chromosomes; the library for chromosome 13 is now complete and other libraries should be available in the near future.

A new initiative involving collaboration between members of the Physics and Life Sciences Divisions at Los Alamos and the Eleanor Roosevelt Institute for Cancer Research is being proposed. In this initiative, a two-dimensional gel protein analyzer is proposed for funding from both the Health Effects Research and the Physical and Technological Research Division that is faster, has greater resolution, and provides a greater dynamic range than do present techniques in the analysis of electrophoretically resolved proteins.

*Ecological Research.* The environmental studies integrate modeling, chemistry, and field ecology experiments to study the problems of the transport and the ultimate fate of pollutants in the environment. Two unique resources, the National Environmental Research Park (NERP) and the Experimental Engineered Test Facility, provide the opportunity to study pollutant transport and behavior in both undisturbed ecosystems and controlled simulations. Of particular interest are the migration of contaminants in a spectrum of ecosystems and the use of data thus gained in controlling contaminant mobility in the environment and understanding the various transport pathways leading to man.

*Physical and Technological Research.* Our long-standing expertise in flow cytometry led to the establishment of the National Flow Cytometry Resource on July 1, 1982, through joint sponsorship of the National Institutes of Health (NIH) and DOE. The major goals of this resource are to make advanced instrumentation available to the biomedical community, to perform R&D in flow instrumentation and relevant methodology, to identify applications, and to provide for

training and dissemination of information. New applications under development include the use of flow cytometry to isolate plant cell hybrids and the combination of flow cytometry with circular intensity differential light scattering (CIDS) to rapidly detect bacteria and viruses.

An application of Los Alamos' capabilities in x-ray physics involves the use of unique soft x-ray facilities to study mechanisms of biological radiation damage and repair in our new initiative entitled "Radiobiology of Ultrasoft X-Rays."

The atmospheric sciences program studies terrain-influenced meteorological transport and diffusion from the balanced viewpoint of experiment and theory. Also, the program studies the constituents of the upper troposphere and lower stratosphere and develops specialized tracers and detection systems for studies of atmospheric dispersion. A developing interest in regional-scale environmental problems is able to benefit from a combination of disciplinary skills assembled in the earlier phases of meteorology and atmospheric chemistry research.

*Nuclear Medicine Applications.* The medical radioisotopes program uses the unique LAMPF to prepare a wide range of medically useful radionuclides. Expertise in target encapsulations, irradiations, radiochemical separations, remote chemical processing, and supporting analytical capabilities has been developed over the years. In addition, a major programmatic effort is directed toward radiopharmaceutical-labeling research, and we are developing a strong effort in organic synthesis. We have also developed the capability to perform *in vivo* studies of the biodistribution and metabolism of labeled biochemicals in animals. Our high-resolution gamma camera permits sequential imaging of labeled compounds *in vivo*.

The stable isotopes programs have focused on applications of stable isotope labeling in combination with nuclear magnetic resonance (NMR) spectroscopy for the noninvasive study of metabolism in microorganisms, cultured cells, isolated perfused organs, and recently, intact animals. This approach to the study of metabolism has shown exceptional capabilities in providing unique and valuable information not available by other techniques. In addition, the medical community has shown interest in NMR imaging and in *in vivo* NMR spectroscopy as safe and noninvasive clinical tools. It is in this context that the new initiative entitled "Development of Topical NMR Methodology and Applications" is proposed.

Our long-standing expertise in the synthesis of compounds that are labeled with the stable isotopes of carbon, oxygen, and nitrogen led to the renewal of the National Stable Isotope Resource (NSIR) under sponsorship of the NIH. The NSIR serves to stimulate the biomedical application of stable isotopes nationally by supplying labeled compounds to external investigators, by publishing new or improved synthetic methodologies in the open literature, and by transferring this technology to industry with a resultant decrease in commercial prices. The current focus of the NSIR core research program is the use of a combination of biosynthetic strategies, involving "methylophilic" bacteria, and chemical synthetic methods, that involve carbohydrates as precursors for the stereoselective production of chiral label compounds. The stereoselective production of labeled compounds is particularly important for the application of compounds labeled with stable isotopes in combination with NMR spectroscopy to the study of metabolic regulation *in vivo*.

LAMPF accelerator-related technology is being applied to the development of biomedical instrumentation for electrosurgery, rf hyperthermia for cancer therapy, and electrothermal techniques for corneal shape modification. An extensive network of collaboration has evolved, permitting the transfer of instrumentation and design to medical schools, hospitals, and the private sector.

## *Initiatives*

### *NATIONAL UNDERGROUND SCIENCE FACILITY*

There are several important scientific experiments that can be characterized as searches for extremely rare events and are very sensitive to the intense flux of cosmic rays. They require enormous amounts of shielding, greatly exceeding what can be supplied in a normal laboratory on the earth's surface. These experiments include searches for spontaneous nucleon decay and for magnetic monopole-catalyzed nucleon decay, certain other searches for magnet monopoles, solar neutrino and cosmic-ray muon experiments, the search for galactic neutrino bursts, neutrino oscillation experiments using the diameter of the earth as the base line, and double beta decay experiments. In addition, the "quiet" environment offered at great depth may make possible new gravity wave experiments, new geophysical observations, and new observations of the gravitational constant at intermediate ranges.

All such experiments currently under way in the US are at modest depths and in working or abandoned mines. There are no deep sites in the US with local technical support facilities where very complex experiments can be carried on without interference from the operations of a working mine. It is widely accepted that such a location will be needed for the next generation of the experiments listed above. European, Japanese, and Soviet scientists already have such dedicated sites. To provide a location in which such experiments can be conducted in the US, the Los Alamos National Laboratory proposes to establish and operate a National Underground Science Facility dedicated to basic research. Present planning is to locate the proposed facility in an open area of NTS where it will be available to any scientist with an appropriate experiment to pursue, subject only to peer review and availability of space. Additional sites, including some in New Mexico, Colorado, and Arizona, are also being examined.

The proposed NTS facility will consist of a 14-ft-diameter vertical shaft initially to a depth of 3,600 ft with laterally excavated chambers to accommodate experiments. In addition to hoist, power, and other utilities, the facility will provide surface technical support in the form of a suitable machine shop, an electronics shop, computer capacity, and dormitory space for scientists. Those working at the facility will therefore have technical support approximating that in their home laboratories and making possible experiments using the most advanced technology of modern science. Operating and support staff will be required, but no increase in scientific full-time equivalents (FTEs) from Los Alamos is anticipated.

In the initial phase of the facility, the shaft will extend to a depth of 3,600 ft and two chambers (40 ft x 200 ft x 46 ft and 30 ft x 50 ft x 25 ft) will be excavated at a total estimated cost of \$52 million. The initial construction will include an exploratory hole to 6,000 ft; and the headframe, hoist, and other features will allow for an extension to a depth of 6,000 ft and for the addition of other chambers at various depths as needed. The operating amount for FY 1985 is for geological exploration, evaluation, and test drilling to prepare for actual construction in FY 1986 and FY 1987.

NATIONAL UNDERGROUND SCIENCE FACILITY						
(\$ in millions - BA)	FY85	FY86	FY87	FY88	FY89	FY90
Operating	0.2	0.2	0.2	2.1	2.3	2.3
Capital Equipment		6.4		0.3	0.3	0.3
Construction		13.9	24.2	7.2	0.0	0.0
Total	0.2	20.5	24.4	9.6	2.6	2.6
Direct Personnel	0	5	10	13	13	13

### *LAMPF II FACILITY*

A proposal is being developed for a major upgrade of LAMPF that will extend US leadership in medium-energy physics into the decade of the 1990s. The complete project involves using LAMPF as an injector for a 6-GeV booster, which in turn feeds a high-intensity, rapid-cycling synchrotron that will increase the maximum energy to 45 GeV and the beam power by a factor of 5 from that of LAMPF. The LAMPF II research program would use intense beams of pions, muons, kaons, neutrinos, and antinucleons to study many aspects of the electroweak and strong interactions.

An initial phase of the LAMPF II project is the construction of a 200- $\mu$ A, 6-GeV booster that in itself will provide the basis for powerful new research programs using kaons and hyperons as well as much more intense beams of muons, pions, and neutrinos. Existing beams of pions and muons would be increased in intensity by a factor of 10 (100 for negative muons), and duty factors would be improved in both directions according to experimental requirements. For those experiments requiring near-continuous sources, duty factors would be increased from the present 6% to 30% or more, and for those requiring well-separated, very intense pulses, they would be reduced to as little as  $10^{-5}$ . The program of decay experiments will be expanded to include the exciting fields of kaon decays and CP violation. Kaon beam intensities will be 100 times higher than those at existing machines in this energy region. The first stage of LAMPF II will also provide the world's best facility for low-energy neutrino physics. For example, the counting rate in neutrino/electron-scattering experiments will be increased by approximately a factor of 30, allowing precision angular distribution measurements where only crude total cross sections exist today.

The preliminary cost estimate for the initial phase of the facility is \$140 million (in FY 1985 dollars), equally divided between the accelerator and the new experimental areas for kaon and neutrino research. An increase in the present LAMPF operating budget will be required to operate the new facility and to carry out the experimental program.

The Los Alamos National Laboratory prepared a physics justification for the proposed facility and is now completing a facility proposal for the accelerator and experimental areas. Given timely funding, a construction start in FY 1987 will be possible. Completion of the construction for the initial phase will be in CY 1991 with commissioning for research in 1992.

LAMPF II FACILITY					
(\$ in millions - BA)	FY86	FY87	FY88	FY89	FY90
Operating	4.0	8.0	8.0	8.0	8.0
Capital	1.0	1.0	1.0	1.0	1.0
Construction	0	35.0	35.0	35.0	35.0
Total	5.0	44.0	44.0	44.0	44.0
Direct Personnel	30	140	140	140	140

### *ZT-H EXPERIMENT*

ZT-H is proposed as the next step in the RFP program at Los Alamos. During a review of fusion development issues, the Magnetic Fusion Advisory Committee recommended proceeding with a ZT-H device capable of 2 MA and upgradable to 4 MA. The importance of extending the current to values in the megampere range in order to test energy confinement was emphasized. Because of budget constraints, DOE proposed a ZT-H capable of only 0.6 MA and upgradable to 2 MA in its FY 1984 Budget Request to the Congress. This device will bring to the fusion program an experimental capability that provides information on confinement scaling with current, ohmic heating, high first-wall heat flux, tokamak-like operating modes, and the physics of high magnetic field shear, MHD beta limits, MHD minimum energy states, and a steady-state current drive technique.

The device will consist of a new discharge chamber with an enlarged-diameter first wall, air core inductive power transfer, motor-generator power supply, and a variable toroidal current from 0.6 to 2.0 MA. Technical goals will include minimization of magnetic field errors, design of plasma limiters for high heat flux, first-wall thermal loadings of 1.5 to 5 MW/m<sup>2</sup>, and steady-state operational capabilities.

DOE proposed funding for ZT-H in its FY 1984 Congressional Budget Request and preliminary design work was initiated in FY 1984. However, the project has not yet received complete DOE/OFE approval. We hope to complete detailed design of ZT-H in FY 1985. Fabrication would be carried out in FY 1986-1988 and installation would be completed in FY 1989. The following table shows the required funding profile for ZT-H.

ZT-H EXPERIMENT					
(\$ in millions - BA)	FY85	FY86	FY87	FY88	FY89
<b>Fabrication</b>					
Operating	1.0	4.0	6.0	4.0	0
FTE*	8	8	10	10	0
<b>R&amp;D Support of Fabrication</b>					
Operating	0	1.5	2.0	2.6	2.6
FTE*	0	10	13	20	20
Total Operating	1.0	5.5	8.0	6.6	2.6
Total FTE*	8	18	23	30	20

\*The majority of these FTEs will be present Laboratory employees, temporary employees, and contract personnel.

### *MOTOR-GENERATOR SET (MGS) FACILITY*

Procurement and installation of a large high-power ( 100-MVA), high-energy (250-MJ) MGS is urgently needed to support the compact advanced confinement research program at Los Alamos. This MGS will store and supply energy to large dc power supplies used in existing and future Los Alamos MFE experiments: the proposed ZT-H experiment as well as extended-performance operation of the current ZT-40M device and CT experiments will require the MGS power facility. Immediate procurement and installation of the MGS are required to capitalize on recent achievements in the RFP program and to extend present program capabilities. The proposed funding profile for the procurement and installation of the MGS is reflected in the following table.

MOTOR-GENERATOR SET (MGS) FACILITY				
(\$ in millions - BA)	FY85	FY86	FY87	FY88
Capital Equipment	0.5	3.0	2.0	0.5
GPP Funds	0.5	0.4	0.3	0.0
Total	1.0	3.4	2.3	0.5
Direct Personnel*	2	3	2	2

\*Present Laboratory employees.

## *REVERSED FIELD PINCH (RFP) IGNITION TEST REACTOR (ITR)/ENGINEERING TEST REACTOR (ETR)*

Successful achievement of the ZT-H experimental goals will contribute significantly to demonstrating that the RFP would lead to a compact, highly competitive magnetic fusion reactor concept using largely state-of-the-art technology. Because of its compactness, achievement of the final commercial goal with the RFP might be accomplished faster and cheaper than with other concepts. The timely implementation of the ZT-H experiment and subsequent successful results would allow the testing of a staged ITR/ETR device based on the RFP principle in the 1996-1999 time frame. Although the primary goal of the RFP program is a compact, steady-state, high-power-density D-T reactor with a direct and credible extension to a D-D reactor system, the RFP still offers advantages as a somewhat larger moderate-power-density system when compared with the large, low-power-density main line.

The ITR/ETR device will address the following reactor issues: (1) reactor current densities for D-T and D-D fuels; (2) ohmic heating to ignition; (3) fusion burn physics, including both D-T and D-D ignition and burn, and refueling/exhaust systems; (4) efficient long-pulsed or ideally steady-state operation with either low-frequency current drive (F- pumping, which is unique to the RFP) or an rf drive being considered for tokamaks; (5) impurity control with divertors as pump limiters; (6) successful design and operation of a high-heat-flux first wall; (7) high-power-density breeding blanket design; (8) radiation damage and component lifetimes at high fluxes; (9) remote maintenance; and (10) net power production. This device has only been considered in the context of long-range technical planning, and therefore preliminary costing has not been carried out.

## *RADIOBIOLOGY OF ULTRASOFT X RAYS*

Ultrasoft x rays provide a unique tool with which to study the physical parameters for the induction of biological lesions because they produce electrons with ranges much less than cellular dimensions but equivalent to those of DNA strands and metaphase chromosomes. Because of an interest in plasma physics diagnostics, highly developed ultrasoft x-ray sources are available to Los Alamos. These sources will be used in a multidisciplinary effort to investigate the biological effects of 0.28- to 8.0-KeV x rays.

The proposed experiments include studies of cell killing under oxic and hypoxic conditions; determination of the cellular age response to low-energy x rays; and measurement of the induction of DNA strand breaks, mutations, and chromosome aberrations. In addition, cell-sorting methods based on cell volume will improve the precision of cell-killing measurements at low doses and enable the measurement of cell survival as a function of cell-cycle position. The major emphasis in the proposed work is to integrate research efforts in physics, biology, and theoretical modeling of radiation action to answer fundamental questions about the mechanism of action of ionizing radiation.

RADIOBIOLOGY AND ULTRASOFT X RAYS						
(\$ in millions - BA)	FY85	FY86	FY87	FY88	FY89	FY90
Operating	0.8	0.8	0.8	0.8	0.8	0.8
Capital Equipment	0	0	0	0	0	0
Construction	0	0	0	0	0	0
Total	0.8	0.8	0.8	0.8	0.8	0.8
Direct Personnel	5	5	5	5	5	5

*CONSTRUCTION AND APPLICATION OF A PROTEIN ANALYZER OFFERING ENHANCED RESOLUTION AND SENSITIVITY*

During the last decade, technologies have been developed that allow the determination and the manipulation of gene composition, structure, and arrangement. Technology for defining patterns of gene expression have not developed to the same extent. Two-dimensional electrophoretic analysis allows determination of the presence and rate of synthesis of many cellular proteins that represent the products of gene expression. This technique, however, is often not adequate for detecting and quantitating important gene products. In this initiative, proteins will be detected with greater sensitivity and resolution than before by using, instead of autoradiography, proportional counting of beta rays emitted from electrophoretically resolved, radiolabeled proteins. A magnetic field will be used to focus the beta rays, and advanced image analysis techniques will be employed in comparing patterns obtained with different samples. These techniques will be applied in studies of patterns of gene expression as they exist or are induced in normal and malignant cells.

CONSTRUCTION AND APPLICATION OF A PROTEIN ANALYZER OFFERING ENHANCED RESOLUTION AND SENSITIVITY						
(\$ in millions - BA)	FY85	FY86	FY87	FY88	FY89	FY90
Operating	1.2	1.3	0.9	0.7	0.7	0.7
Capital Equipment	0.1	0.1	0	0	0	0
Construction	0	0	0	0	0	0
Total	1.3	1.4	0.9	0.7	0.7	0.7
Direct Personnel	7	7	5	4	4	4

## *DEVELOPMENT OF TOPICAL NMR METHODOLOGY AND APPLICATIONS*

In conjunction with the rapidly expanding interest and effort in medical and biological NMR, Los Alamos is seeking support for a new initiative in NMR technologies. In particular, we propose several new schemes for expanding *in vivo* metabolic studies. One is the semitoroidal rf coil (for which US and foreign patents applications were made in 1983 and 1984) which can be used as the main NMR coil or as a second irradiation (decoupling) coil with reduced dielectric heating and increased directionality. Another approach is a magnet that generates a region of static field outside itself (rather than inside or between components) for which a new US patent has been applied in 1984. Such a magnet could radically change the geometry and uses of whole-body NMR machines because the object of interest would no longer have to fit within a certain space and the accessibility to the sample space could be vastly improved. We propose to construct and assemble such a usable NMR spectrometer over the next several years. If the prototype is successful, the process can be iterated for the following several years to produce a state-of-the-art research apparatus.

This initiative will also contribute significantly to the success of the Center for Non-Invasive Diagnosis, located at the University of New Mexico (UNM) Medical School in Albuquerque. This Center is being developed as a joint project between the staff at Los Alamos National Laboratory and faculty at the Medical School; the director has a joint appointment at the Laboratory and at UNM. The Center is expected to provide exceptional opportunities for synergistic collaborations between clinical and basic medical scientists at the Medical School and biochemists, physicists, and spectroscopists at Los Alamos. The unique isotope production capabilities at Los Alamos and the expertise in light-isotope separation, isotope synthesis and labeling, and NMR spectroscopy and instrumentation at Los Alamos are contributions of crucial importance. Investigations of metabolism in model systems for normal and diseased states using stable isotopes and NMR spectroscopy are necessary to develop and identify the NMR methodology and isotope-labeling strategies that are likely to have diagnostic utility in humans.

DEVELOPMENT OF TOPICAL NMR METHODOLOGY AND APPLICATIONS						
(\$ in millions - BA)	FY85	FY86	FY87	FY88	FY89	FY90
Operating	0.2	0.3	0.4	0.5	0.5	0.3
Capital Equipment	0.05	0.1	0.1	0.1	0.1	0
Construction	0	0	0	0	0	0
Total	0.25	0.4	0.5	0.6	0.6	0.3
Direct Personnel	1	2	2	2	2	1

## *DEVELOPMENT OF COHERENT VACUUM ULTRAVIOLET LIGHT SOURCE*

Substantial progress has been made in recent years in the generation of tunable radiation in the VUV/XUV region by laser nonlinear optical techniques. The generation of continuously tunable radiation from 70 to 200 nm is now possible. The objective of this initiative is to develop a fully

engineered, movable VUV/XUV radiation source system using state-of-the-art techniques and the considerable expertise that exists at Los Alamos in excimer and dye lasers, in nonlinear optics in general, and in developing pulsed valves and nozzle expansions to generate a confined region of high-density, nonlinear medium.

Synchrotron light sources have been developed to provide the higher intensities necessary for modern photochemistry research and technology. By simultaneously providing high-peak power and high resolution, laser-based light sources can provide an important adjunct to synchrotron sources. The unique feature of a laser-based source is that its relatively low cost and transportability will allow it to become a widely used analytical instrument with greater access by more researchers and for longer periods of time. Once the development work on such a laser-based system has been completed through a Los Alamos program, details would be made available to the scientific community for duplication and to the private sector for possible commercial development. The first 3 years of this project will be directed toward laser development; subsequently, most of the effort will be devoted to laser applications.

DEVELOPMENT OF COHERENT VACUUM ULTRAVIOLET LIGHT SOURCE						
(\$ in millions - BA)	FY85	FY86	FY87	FY88	FY89	FY90
Operating	0.7	0.5	0.5	0.5	0.5	0.5
Capital Equipment	0.1	0.1	0.1	0	0	0
Construction	0	0	0	0	0	0
Total	0.8	0.6	0.6	0.5	0.5	0.5
Direct Personnel	5	3	3	3	3	3

### *HEAVY-ION FUSION ACCELERATOR RESEARCH*

Driving an ICF target with a heavy-ion beam has promise for a fusion system suited to energy applications. Los Alamos is lead laboratory for this effort, with approximately \$9 million proposed in FY 1985 for accelerator R&D. Most of this work will be carried out in induction linac accelerator development at LBL. The national accelerator inertial fusion plan calls for completion of an experimental accelerator capable of driving a target to a temperature greater than 50 eV by FY 1989. No decisions have yet been made concerning such a facility; however, if the accelerator is built at Los Alamos, the following budget profile is projected.

HEAVY-ION FUSION ACCELERATOR RESEARCH						
(\$ in millions - BA)	FY85	FY86	FY87	FY88	FY89	FY90
Operating	2.7	4.2	4.0	4.0	4.0	4.0
Construction	0	0	15.0	15.0	15.0	0
Total	2.7	4.2	19.0	19.0	19.0	4.0
Direct Personnel	12	18	18	18	18	18

## NUCLEAR ENERGY

B & R Code	Major Program	(\$ in Millions - BA)		
		FY 1984	FY 1985	FY 1986
AE	Advanced Nuclear Systems	5.7	7.0	11.8
AF	Breeder Reactors	10.7	8.0	6.3
AG	Converter Reactors	0.2	0.7	0.6
AH	Remedial Action Programs	0.0	0.3	0.2
AS	Nuclear Fuel Cycle	0.1	0.1	0.0
CD	Uranium Enrichment	0.4	0.1	0.1
Total		17.1	16.2	19.0
Percent of Laboratory Funding		2	2	2

### Current Programs

#### SPACE AND TERRESTRIAL APPLICATIONS

*Radioisotopic Heat Sources.* This program provides support to DOE and the ultimate users in National Aeronautics and Space Administration (NASA) and DoD for the safety evaluation, testing, materials qualification, and design-related aid for radioactive heat sources. Two heat sources, based on Los Alamos designs, will be used to power the on-board instrumentation for the spacecraft to be used in the Galileo and International Solar-Polar missions. Support is also provided for terrestrial heat source programs. The production Light-Weight Heater Units will be delivered to NASA.

*Space Technology Program (SP-100 Program).* Historically, this program focused on development of advanced reactor concepts for use in space. A major change in emphasis took place during FY 1983 with the designation of Los Alamos National Laboratory as Deputy Project Manager for Nuclear Technology for a triagency [DOE, Defense Advanced Research Projects Agency (DARPA), and NASA] effort to produce a flight-qualified reactor by the early 1990s. The Jet Propulsion Laboratory acts as the SP-100 Project Manager and coordinates overall system definition, which includes aerospace and power conversion technology as well as safety and nuclear technology. Therefore, Los Alamos moved into a management and technology support role for evaluation of a variety of reactor concepts developed by industry with triagency funding. The heat-pipe reactor concept, previously investigated at Los Alamos, was evaluated in the industrial studies. Los Alamos also has total responsibility for safety in the technology assessment and advancement phase of the program (FY 1983-1985).

In addition to management of the technology development in support of the SP-100 reactor subsystem, the Laboratory has begun specific tasks in fuels and materials and primary-heat-transport-system components development. A reactor design and assessment task serves to integrate technically this work and that done by others in the overall program. The goal of this effort is a technology base upon which to found a choice of reactor systems for the next Ground Engineering Test phase.

Overall system design parameters include low weight and volume, long life, reliability, and flexibility to meet various user requirements, whether deep-space exploration or DoD surveillance and communication. Currently, Los Alamos is also participating in planning for the ground engineering phase. It is not anticipated that reactor ground testing will be conducted at Los Alamos. The Laboratory will maintain back-up capability for testing of various reactor system components.

### *LMFBR BASE PROGRAM*

Los Alamos contributes to the LMFBR Base Program in three technology areas: core systems, physics, and safety. The core systems projects are focused on the development of uranium/plutonium carbide as an LMFBR advanced fuel. Physics and safety projects and a new initiative in core design were combined with the core systems projects to constitute a program at Los Alamos with the objective of developing an advanced LMFBR core and reactor design optimized to the carbide's unique properties and behavior. The core systems projects continue to concentrate on demonstrating the irradiation performance of carbide fuels. The Los Alamos Hot Cell Facility supports this work. The physics, safety, and core design work was focused on the design and analysis of a small, modular reactor system. The core systems, design, and safety work will be continued in FY 1985 and is expected to focus on a large, pool-type reactor system. Physics work that is not central to the design effort will be terminated. The base program support for the Hot Cell Facility is also expected to be reduced significantly.

Several new initiatives addressed to assessment of the market and complementary reactor concepts have been proposed and are expected to win DOE support. The products of these initiatives are expected to influence strongly the direction and scope of continued reactor technology development by the Department.

### *REMEDIAL ACTION*

The decommissioning of the outside structures associated with the Water-Boiler Reactor is planned for FY 1986. Planning for the decommissioning of the TA-52 Ultra High-Temperature Reactor Experiment facility (UHTREX) will begin in FY 1986 with actual decommissioning in FY 1987 and FY 1988. In FY 1989 and FY 1990, the decommissioning of the Water-Boiler Reactor will be completed.

Los Alamos personnel have had extensive experience in such efforts. Many other Federal and non-Federal facilities that have been used for radioactive studies are becoming candidates for decommissioning. Several commercial nuclear reactors will be decommissioned by the end of the century. A modest effort at this time will have significant application to a variety of needs as they develop through the 1980s and 1990s.

## *Initiatives*

In harmony with the Laboratory's assigned management role in the Space Reactor Program and its Defense Programs' initiative in Military Energy Security, other reactor concepts are being investigated for military applications. The Assistant Secretary for Defense Programs has instructed the Albuquerque Operations of the DOE to assess military needs for secure energy sources. Secure energy has the connotation of base-load power for bases in the continental United States.

A second assessment is concerned with a long-lived unattended power supply for remote sites such as Defense Early Warning (DEW) Line radars—North Warning System (NWS).

### *DEFENSE TERRESTRIAL REACTOR (DTR)*

The Laboratory, in its role of supporting national security through R&D, has initiatives under way in these military applications. The DTR Program has investigated the feasibility of meeting military need for secure power supplies and concluded that the military requirements can best be met with nuclear reactors. We expect external funding to begin this fiscal year.

DEFENSE TERRESTRIAL REACTOR (DTR)						
(\$ in millions - BA)	FY84	FY85	FY86	FY87	FY88	FY89
Operating	0.25	1.0	1.0	1.0	1.0	1.0
Capital Equipment	0.0	0.2	0.1	0.1	0.1	0.1
Total	0.25	1.2	1.1	1.1	1.1	1.1
Direct Personnel	2	6	6	6	6	6

### *NORTH WARNING SYSTEM*

For the remote site applications, a Los Alamos study indicates that these applications, too, are most cost-effectively satisfied by a small nuclear power plant employing thermoelectric conversion. Comparisons were made on the basis of a 20-year life cycle, considering diesel reciprocating engines, fuel cells, and Rankine cycle options. The NWS reactor study is funded jointly by USAF and DOE/Defense Programs (DP) and aims at supplying unattended, reliable power for arctic application.

NORTH WARNING SYSTEM			
(\$ in millions - BA)	FY84	FY85	FY86
Operating	0.8	2.5	2.5
Capital Equipment	0.0	0.2	0.2
Total	0.8	2.7	2.7
Direct Personnel	5	15	15

### *MULTIMEGAWATT PROGRAM*

The Space Reactor Program will be concentrated in the hundred-kilowatt to multimegawatt power regime. However, shielding requirements in deep space are obviously not as stringent as for terrestrial applications even at remote sites. Further, there are certain energy requirements at much lower power levels, that is, 5-50 kWe. Therefore, the military applications and space reactor projects complement one another very well.

MULTIMEGAWATT PROGRAM							
(\$ in millions - BA)	FY84	FY85	FY86	FY87	FY88	FY89	FY90
Operating	0.4	3.0	4.0	6.0	6.0	6.0	6.0
Capital Equipment		0.2	0.2	0.2	0.2	0.2	0.2
Total	0.4	3.2	4.2	6.2	6.2	6.2	6.2
Direct Personnel	3	15	18	25	25	25	25

Capital Equipment costs have not yet been defined and it is unlikely that construction will begin before 1990.

As part of a New Initiatives approach, further definition and requirements will be made by appropriate interactions with senior military personnel. Los Alamos will then perform an assessment of current available designs and make recommendations as to which of these should be selected for further study leading to a complete, deliverable system.

## CONSERVATION AND RENEWABLE ENERGY

B & R Code	Major Program	(\$ in Millions - BA)		
		FY 1984	FY 1985	FY 1986
AL	Energy Storage Systems	1.8	1.7	3.4
AM	Geothermal	7.7	7.2	6.5
EB	Solar Energy	1.3	0.6	1.8
ED	Industrial	0.3	0.4	0.4
EE	Transportation	0.1	0.2	0.7
EG	Multi-Sector	0.6	0.6	0.7
	Total	11.8	10.7	13.5
	Percent of Laboratory Funding	2	1	1

### Current Programs

#### ENERGY STORAGE SYSTEMS AND VEHICLES AND ENGINE R&D

The superconducting magnetic energy storage (SMES) is in the demonstration phase. The operating coil has been installed on the Bonneville Power Administration lines between Washington State and Los Angeles. All but one of the planned experiments have been performed successfully and the system was recently shut down. Los Alamos plans to continue feasibility studies in FY 1985 and FY 1986 on the commercial applications of SMES.

Fuel cells for transportation applications, funded by the Office of Energy Systems Research (OESR) and Vehicle and Engine R&D (VERD), is a two-part program to determine the feasibility of fuel cells as power supplies for consumer vehicles, buses, locomotives, and ships. The basic research part of the program takes advantage of the Laboratory's capability in electrochemistry and catalysis, focusing on alternative catalysts, size reduction, performance increases, and cost reduction. The applied research portion uses the systems integration, modeling, technology assessment, and economics capabilities of the Laboratory.

Los Alamos proposes to enhance our program in electrochemistry, catalysis, and the thermal and mass transport behavior of reformers. This program addresses the problems of materials, compatibility, and rapid response of fuel cells to demands that are characteristic of a transportation system. Fuel cells can be a primary component of small defense energy electrical supplies. Direct application to both mobile and stationary power supplies is being investigated. We are anticipating growth in the basic research portion of the fuel cell electrochemistry and catalysis program to \$4-5 million per year beginning in FY 1985.

These programs are supported by feasibility studies being conducted at Los Alamos on the use of fuel cells in buses, funded by the Department of Transportation (DOT) (\$300 thousand) and in an advanced light, land combat vehicle, funded by DARPA (\$100 thousand).

## *GEOHERMAL*

Virtually all geothermal energy produced today involves extraction of naturally occurring subsurface hot water or steam, removal of the thermal energy, and reinjection of the spent fluid. The Los Alamos Hot Dry Rock (HDR) concept is unique in that it requires only high subsurface temperatures and relatively impermeable rock. Naturally occurring hot rock is far more abundant than the combination of hot rock, adequate permeability, and water or steam. Extraction of thermal energy from hot dry rocks requires creation of a subsurface fracture system (heat exchanger) connected to the surface by well bores capable of injecting cold fluid, providing pathways through the fracture system for fluid heating, and returning the hot fluid to the surface. At the surface, the thermal energy is extracted and the fluid is then reinjected in a continuous closed-loop operation.

A small (5-MWt) HDR research reservoir was created at Fenton Hill, and a 60-kW binary system turboalternator was run from this energy source. In 1984, a larger reservoir has been formed, and work is under way to establish a fractured-zone connection between two nominal 15,000-ft wells, early in 1985, capable of producing electrical power in the range of 20-40 MWt. At the completion of this demonstration, the power plant may be turned over to a local utility. The Federal Republic of Germany and Japan participate with financial assistance of \$2.5 million each per year and with resident staff. This contribution can be expected to continue through FY 1985, and negotiations are currently under way to extend it through FY 1986. The funding for the Los Alamos HDR program is anticipated to be at least \$2 million greater than the President's Budget Request because of recent discussions with DOE Headquarters personnel that indicate that the instrumentation R&D portion of the HDR program might be funded separately at this level.

## *COMBUSTION TECHNOLOGY*

Under the Combustion Technology Program, we have been modeling material flow, thermochemistry, and heat transfer to determine the patterns in internal combustion engine cylinders. In FY 1984, a funding level of \$585 thousand was allocated to develop a reaction flow model for this program. Fossil Energy has recently funded a supporting program to use the same hydrodynamic techniques for modeling combustion of coal/water mixtures (\$165 thousand).

## *INDUSTRIAL CONSERVATION*

In FY 1983, Los Alamos initiated a program jointly with DOE and the American Iron and Steel Institute to apply laser instrumentation developed under other Laboratory programs to the on-line, real-time analysis of molten steel in its production. If successful, this technology can provide energy savings through less metal waste to the metal production industries.

## *SOLAR*

The Laboratory continues to be recognized worldwide as the leader in active and passive solar heating and cooling of buildings. The passive solar programs are expected to continue in materials and systems analysis and assessment. The Laboratory's program is performed in cooperation with industry and the Solar Energy Research Institute. The program is anticipated to remain at a funding level of \$1-1.5 million.

We also maintain a level-of-effort program in active solar heating and cooling, again concentrating on systems analysis and materials.

## *Initiatives*

### *ELECTROCHEMISTRY AND CATALYSIS*

An expanded program in Catalysis and Electrochemical Systems Research is proposed. It would be funded by DOE/OESR.

Catalysis and electrochemistry systems research is needed to advance the state of the art and commercial viability of fuel cells, batteries, corrosion, electrochemical synthesis, electrolysis, and electroplating. Battery, fuel cell, and photoelectrochemical conversion costs can be reduced, and power density, reliability, and life can all be increased by this research. The proposed program would draw from the expertise that currently exists in the Laboratory's Chemistry, Materials Science and Technology, Electronics, and Theoretical Divisions. Unique instrumentation methods developed at Los Alamos have provided new insights into the electrochemical process. Those methods will benefit an expanded program.

Catalysis research can play a major role in reducing costs by finding alternatives to noble-metal catalysts or by better use of these traditional materials. Corrosion of metals such as those used in piping, ships, and automobiles currently costs the nation upwards of \$10 billion per year. A better understanding of the electrochemistry of corrosion could significantly reduce this cost. New materials that currently cannot be fabricated can be made by electrochemical synthesis; additional research is needed to advance this emerging technology. Catalysis and electrochemistry systems are the basis of electrolysis, which has applications for fuel production (hydrogen) and energy storage. More efficient electrolysis, coupled with nuclear power, for hydrogen production could increase the capabilities of refineries that use low-grade oil or could create the opportunity for use of hydrogen as a fuel. The proposed coherent program encompasses sciences involving materials, theoretical surface physics, instrumentation, and chemistry, all fundamental to Los Alamos research.

ELECTROCHEMISTRY AND CATALYSIS						
(\$ in millions - BA)	FY85	FY86	FY87	FY88	FY89	FY90
Operating	3.0	3.0	3.0	5	5	5
Direct Personnel	20	20	20	20	20	20

## FOSSIL ENERGY

The Fossil Energy Program continues to focus the strength at Los Alamos in areas of computer modeling, instrumentation and control, advanced materials development, process chemistry, and engineering on fossil energy applications.

B & R Code	Major Program	(\$ in Millions - BA)		
		FY 1984	FY 1985	FY 1986
AA	Coal	1.6	0.8	2.3
AB	Gas	0.4	0.6	0.5
AC	Petroleum	1.5	1.0	2.6
CV	Oil and Gas Development	0.0	0.0	0.1
Total		3.5	2.4	5.5
Percent of Laboratory Funding		1	<1	1

### Current Programs

#### COAL

Los Alamos National Laboratory is continuing to develop state-of-the-art, laser-based, noninvasive diagnostic techniques for *in situ* measurements in coal gasification process streams. Several field tests have been completed using the Morgantown Energy Technology Center's (METC's) gasifiers.

A structural ceramics program has been initiated under the DOE Fossil Energy Advanced Research and Technology Development Program. One facet of this program is producing SiC whiskers with tensile strengths exceeding 500,000 psi. These whiskers are being used in conjunction with plasma-produced ultrafine powders to fabricate composite structures. The goal is to manufacture fracture tough, high-temperature, heat-resistant ceramic parts for heat exchanges and components of coal gasifiers.

Fuel cell electrochemistry and systems analysis, synergistic with the Conservation-funded Fuel Cell Transportation Applications and Electrochemistry and Catalysis program, is continuing in FY 1985 and FY 1986.

#### GAS

The Laboratory has initiated a new program jointly with METC on the direct conversion of methane to methanol. The proposed process uses a plasma to create free radicals in a side stream of methane, which when recombined with the main stream, produces methanol. Funding is expected to be \$0.3-0.5 million per year for this program in FY 1984-1986.

## *OIL SHALE (PETROLEUM)*

A major reorientation in the Oil Shale Rock Fragmentation Program as applied to *in situ* retorting is taking place. The field work at Anvil Points is complete and data analysis coupled with modeling is continuing. Laboratory experiments to validate a protocol to characterize explosives are under way.

As a result of encouraging guidance that Los Alamos has received from DOE Headquarters, METC, and the Laramie Project Office as well as a request by the Oil Shale Peer Review Committee, the out-year funding for oil shale is projected to grow to \$2-3 million by FY 1986, primarily in the areas of siting methodology.

## *Initiatives*

### *OIL SHALE*

The Laboratory, in recognition of the importance of fossil energy base technology development, has allocated both ISRD and program management resources to fossil energy R&D relative to defense; this, combined with the projection of a very substantial technical opportunity, has motivated the development of new initiatives. The internal program elements have been organized into five basic technical approaches: modeling, sensors and instruments, advanced materials, modern chemistry and engineering, and system studies. The strategy has been to establish a firm foundation and to focus on opportunities that provide a long-term benefit to the Laboratory.

Los Alamos is being considered for the technical leadership role to help METC restructure the oil shale program. Specifically, the Laboratory has been asked to contribute to a 5-year plan for the DOE oil shale program. We are to have the overall responsibility of coordinating siting methodology studies as well as to take a lead R&D role on selected topics (air quality and dispersion modeling, for example).

OIL SHALE							
(\$ in millions - BA)	FY84	FY85	FY86	FY87	FY88	FY89	FY90
Operating	0.3	1.5	2.0	2.5	3.0	3.0	3.0
Direct Personnel	1	10	15	18	20	20	20

## *INTERNATIONAL AFFAIRS AND ENERGY POLICY*

B & R Code	Major Program	(\$ in Millions - BA)		
		FY 1984	FY 1985	FY 1986
NA	International Affairs	0.0	0.1	0.1
Percent of Laboratory Funding		<1	<1	<1

### *Current Programs*

Current international energy programs aim at enlarging the Los Alamos program of international technology cooperation in support of foreign policy initiatives by the Department of State (DOS), the Agency for International Development (AID), and DOE.

There are several current activities in support of the above objective, including development of cooperative agreements with the Mexican Nuclear Research Institute (ININ) and the Mexican Petroleum Institute (IMP) for the purpose of conducting joint research.

Analytical support is being provided to DOE on electric utility policy issues in areas such as financing of capacity expansion, electricity conservation efforts, power wheeling for oil and gas use reduction, and international nuclear issues.

An energy and minerals component of the Caribbean Basin Initiative has been developed to assist countries in that region to develop indigenous energy and mineral resources essential to their economic development and to reduction of their dependence on high-cost imported oil. A geothermal assessment of the Qualibou Caldera on St. Lucia has been completed as have mineral assessments of St. Lucia and St. Vincent. A reconnaissance assessment of some of the peat resources of Costa Rica has also been completed. Discussions continue on similar projects in Honduras, Costa Rica, Dominica, and the Dominican Republic.

## *Initiatives*

### *CARIBBEAN BASIN AND CENTRAL AMERICA*

The Caribbean countries have expressed considerable interest in various aspects of the energy and minerals component as an essential vehicle for developing secure energy sources that will assist their economic development. Costa Rica, the Dominican Republic, and Jamaica have also expressed interest in this component.

The primary difficulty in implementing a substantial program in the region is funding. AID and the international banking community appear to be the most likely sources for funds. If the program can be reasonably funded initially, there appears to be a likelihood that other countries in Latin America will be interested in participating and sharing the cost of work done there.

### *US/MEXICO COOPERATION*

Los Alamos-ININ nuclear cooperation has a good beginning despite Mexico's current economic problems and the budget constraints of the US Government. In FY 1982, Los Alamos and ININ scientists conducted joint research in economies of scale by reactor size, expansion of the Mexican nuclear electrical system, and design and construction of a research reactor. Exchanges of scientific personnel between Los Alamos and the Center for Nuclear Studies at the National Autonomous University of Mexico (UNAM), in such areas as neutron activation analysis and radioisotopes and nuclear medicine, would greatly enhance the scope of cooperation if DOE support can be obtained. The Los Alamos-IMP agreement negotiated in FY 1983 has been approved by the new Mexican Government, and joint research activities are anticipated to continue.

*POLICY, SAFETY, AND ENVIRONMENT*

B & R Code	Major Program	(\$ in Millions - BA)		
		FY 1984	FY 1985	FY 1986
HA	Overview and Assessment	1.5	2.1	3.4
PE	Policy Analysis & Sys Studies	0.3	0.3	0.3
UF	Env-Emergency Preparedness	0.0	0.1	0.0
	Total	1.8	2.5	3.7
	Percent of Laboratory Funding	<1	<1	<1

*Current Programs*

Ongoing programs for the Assistant Secretary for Policy, Safety, and Environment (HA-01) provide technical support and management of projects designed to identify health and environmental hazards relating to energy resource development and operations at DOE facilities. The future focus of these programs will be to develop recommendations on control of radioactive materials in the environment, to train DOE personnel on criticality safety, to provide industrial hygiene support for evaluation and control of occupational health hazards in the operation of developing energy technologies, to assist in the development and overview of safety analysis review systems at DOE facilities, and to complete a computer method to analyze results of accidental explosions in nuclear facilities.

There are a total of seven programs under this category. Their funding is delineated in the Summary of Estimates (1-B-4). The A304 program, Explosion Modeling Within Structures, will be completed in FY 1985. The other programs will have level funding or modest increases in activity in FY 1985 and FY 1986.

The Los Alamos National Laboratory is also performing a vulnerability assessment of oil and natural gas offshore platforms. This activity is synergistic with a task funded by DoD to develop an energy vulnerability assessment handbook for military bases.

## *NUCLEAR WASTE POLICY PROJECT OFFICE*

### *NUCLEAR WASTE FUND ACTIVITIES*

The Nevada Nuclear Waste Storage Investigations (NNWSI), which is a part of the national program to evaluate different types of geologic media for ultimate disposal of high-level waste, is evaluating a region of NTS for this purpose. The evaluation is to determine whether a potentially acceptable site exists for a commercial waste repository. Scientists from Sandia National Laboratories, Los Alamos National Laboratory, Lawrence Livermore National Laboratory, and the US Geological Survey are participating in the site evaluation.

Los Alamos has the responsibility for the characterization of geochemistry and mineralogical aspects of the site that would contribute to waste isolation. In addition, Los Alamos is responsible for the design and construction of an exploratory shaft at the Nevada Test Site and coordination of experiments to be conducted in the shaft. Data from the experiments will provide detailed site characterization for purposes of evaluating the site against other proposed repository sites.

B & R Code	Major Program	(\$ in Millions - BA)		
		FY 1984	FY 1985	FY 1986
DB	Nuclear Waste Fund	9.5	1.3	14.6
Percent of Laboratory Funding		1	<1	2

## WORK FOR OTHER DOE INSTALLATIONS

B & R Code	Major Program	(\$ in Millions - BA)		
		FY 1984	FY 1985	FY 1986
	Work for Other DOE	27.4	30.3	26.1
	Percent of Laboratory Funding	4	4	3

The Laboratory anticipates accomplishing about \$23.0M worth of work for other DOE organizations during FY 1984. A wide range of materials and services is provided to a number of Department of Energy entities, much being based on one-of-a-kind orders. Thus, it is difficult to estimate many of the individual components of this reimbursable work category with precision. The total level of the work can be estimated with a bit more confidence, and this is expected to increase nominally in FY 1985.

## WORK FOR OTHERS (WFO)

B & R Code	Major Program	(\$ in Millions - BA)		
		FY 1984	FY 1985	FY 1986
	Department of Defense	49.4	49.0	55.0
	Nuclear Regulatory Commission	15.3	13.1	13.3
	Other	21.5	25.9	24.5
Total		86.2	88.0	92.8
Percent of Laboratory Funding		13	12	10

## DEPARTMENT OF DEFENSE

### *Current Programs*

#### *ENERGY R&D*

The DoD Energy R&D Program is designed to provide a coherent effort to meet the energy needs of the military. Since 1980, the Laboratory has hosted three workshops on energy for DoD that have addressed means by which DOE energy research capabilities can be applied to DoD requirements. The Laboratory has thus far focused on identifying vulnerabilities and on conducting R&D that promises to help provide secure energy supplies for the future. The program looks at both near- and long-term needs. It has the potential of becoming a central resource for assisting DoD in fulfilling its energy needs.

Energy Security has focused on assessment of the vulnerabilities of Air Force bases and critical missions to commercial electric power outages. The work includes development of vulnerability assessment methodology, validation of the methodology, and then documentation of the methodology to provide a step-by-step handbook of procedures. The handbook will permit Air Force base engineers to do their own assessment of base vulnerabilities and needs.

Los Alamos is also conducting analyses and assessments of the potential applications for fuel cells and small nuclear reactors in the 1990-2000 time period. The review will also assess the validity of the various application studies conducted to date. Applications to be investigated include submarines, surface vessels, space laser systems, remote sites, vehicles (both transport and combat), and base-load-power surface generators.

## *INTERNATIONAL TECHNOLOGY*

The International Technology Division reimbursable programs for the DoD are based on year-by-year tasking for a variety of sponsors. These include the Defense Intelligence Agency, DNA, the National Security Agency, the US Air Force, the US Army, the US Navy, and Headquarters elements of DoD.

The subjects studied depend upon current events, politics, and the state of technologies of concern to those who bear responsibility for the security of the United States. For example, a surge in directed-energy tasking was initiated following the President's address on technological defense against ballistic missiles. These programs are undertaken only when the interests of DOE and the sponsoring agency are in accord with the scientific talents and capabilities available at the Laboratory.

## *CONVENTIONAL ORDNANCE AND MATERIALS TECHNOLOGY*

Expert knowledge about materials, high explosives, and the interactions so essential for nuclear weapons development is being applied to DoD materials and conventional ordnance problems. Examples of Laboratory programs are those for ceramic armor and improved antiarmor projectiles. Work has been started on advanced projectiles and propellants for army artillery and direct fire guns and a variety of concepts for antisubmarine warheads. High-explosive work under way involves the understanding and development of safer insensitive high explosives and general studies of high-explosive physics and chemistry.

## *NUCLEAR, BIOLOGICAL AND CHEMICAL WARFARE (NBC) COUNTERMEASURES*

The NBC countermeasures program uses established R&D capabilities to develop antidotes for chemical agents and toxins, evaluate protective systems, provide adequately sensitive nuclear, biological, and chemical detection and warning systems, and devise suitably effective and economical methods for decontamination of equipment and demilitarization of the current obsolete chemical weapon stockpile. The program includes the aggregate of human-effects-oriented projects supported by the DoD. Special facilities and combinations of scientific disciplines enable the Laboratory to approach the complex problems which stem from the possibility that a future conflict may involve the use of nuclear, biological, chemical, and directed-energy weapons. Integrated effects studies involving measurement and assessment of the consequences of weapons combinations must anticipate incompatibilities of countermeasures, rank order threats, and ensure operational effectiveness in the future battlefield environment. The results of these studies are crucial for planning and developing defenses and countermeasures on the integrated battlefield.

## *Initiatives*

The Strategic Defense Initiative, in response to President Reagan's March 23, 1983, address to the nation, is dedicated to exploration of technologies that may negate the threat of ballistic missiles. The most desirable outcome would be to develop defensive weapons that do not require nuclear detonations with the attendant fallout and other collateral effects and that are furthermore not threatening as offensive weapons. It is further highly desirable that these defensive weapons be capable of destroying offensive threat ordnance at ranges of thousands of kilometers with the highest possible transit speeds. Power requirements dictate that the energy must be highly preferentially directed.

These conditions are, potentially, optimally satisfied by either electromagnetic quanta or relativistic beams of atomic or subatomic particles. In the latter case, electrically neutral particles are much preferred because their trajectories are not perturbed by the earth's magnetic field. The free-electron laser and neutral particle beam programs at Los Alamos, both based on our decades of experience at the frontiers of accelerator technology research and development and described below, are highly promising elements of the overall national SDI program.

We have been assisting the Department of Defense for many years with SDI-related reimbursable programs of a smaller size, ranging from a million dollars a year to a few thousand. While these smaller programs are generally planned from year to year, we expect to continue in the future at about the same total level (about 20 programs totalling three million in FY 1984).

### *FREE-ELECTRON LASER—DEFENSE ADVANCED RESEARCH PROJECTS AGENCY (DARPA)*

Recent results obtained at Los Alamos National Laboratory have demonstrated an order-of-magnitude increase in the efficiency and power of free-electron lasers and confirmed theoretical predictions. These results, which represent the best performance achieved to date, have generated considerable interest in free-electron lasers for high-power strategic applications. Los Alamos is uniquely capable of developing such lasers because of its broad expertise in lasers and electron accelerators. At the current time, the Laboratory program is sponsored by the Army Ballistic Missile Defense Project Office and DARPA. The objective is to demonstrate, on a small scale, a complete high-efficiency free-electron laser system embodying the technology required for a high-power device. This program will be completed in FY 1986. In addition, work has begun on scaling critical elements of the small-scale technology to levels required for a high-power device. This effort would logically be followed by the construction of a high-power device over the period FY 1986 to FY 1991.

FREE-ELECTRON LASER				
(\$ in millions - BA)	FY87	FY88	FY89	FY90
Construction	3.2	19.5	65.0	96.3

## *TECHNOLOGY DEMONSTRATION ACCELERATOR (TDA)—US ARMY*

Los Alamos has systematically explored the feasibility of neutral particle beam weapons using rf accelerator technology; the results have caused sharply increasing interest in the use of neutral particle beams for strategic defense applications. Los Alamos has a unique capability in linear accelerator technology, and at present conducts an Army, Air Force, and DARPA-sponsored accelerator test program to demonstrate the injector and preliminary accelerator stages. The Army and Air Force are planning in FY 1986-1990 to build a TDA facility that would contain all the major components to allow testing of the negative-ion accelerator, output optics, and neutralizer cell. The TDA would be an intermediate step to a weapon prototype; it would be used to verify design choices and to identify problem areas.

TECHNOLOGY DEMONSTRATION ACCELERATOR						
(\$ in millions - BA)	FY85	FY86	FY87	FY88	FY89	FY90
Construction	4.0	10.0	24.0	40.0	40.0	30.0

## *COUNTERTERRORISM*

We are in the developmental stages of a Laboratory Counterterrorism Program and have a number of project ideas submitted for outside sponsorship. The successful development of this program depends on the quality of these project proposals; moreover, some will undoubtedly need small amounts of seed money for proof-of-principle or other demonstration.

COUNTERTERRORISM				
(\$ in millions - BA)	FY84	FY85	FY86	FY87
Operating	1.0	2.0	4.0	6.0
Capital Equipment	0.1	0.2	0.2	0.2
Total	1.1	2.2	4.2	6.2
Direct Personnel	8	12	20	28

## *NONNUCLEAR WEAPONS*

The Laboratory, along with LLNL and SNLA, will have an expanded role in conventional munitions development. A joint Los Alamos/LLNL/SNLA initiative will be block funded by the DoD and will be under Laboratory technical management. Los Alamos will apply its unique capabilities in the areas of explosives technology, computer simulation, and engineering development to R&D to improve conventional weapons.

BLOCK FUNDING FOR NONNUCLEAR WEAPONS				
(\$ in millions - BA)	FY85	FY86	FY87	FY88
Operating	10.0	12.0	15.0	20.0
Direct Personnel	40	45	60	80

## *NUCLEAR REGULATORY COMMISSION (NRC)*

The NRC work at Los Alamos focuses on providing an understanding of the behavior of nuclear reactor systems under postulated accident conditions and on providing assistance in reactor licensing. This is done mainly through development, testing against experimental data, and application of advanced computer codes that model accident behavior. All major reactor types are considered, with the emphasis adjusted as NRC needs and priorities evolve. Most of the safety effort has been concerned with light-water reactors (LWRs).

The cornerstone of the Los Alamos effort is the well-developed TRAC computer code, which has been tested satisfactorily against data from pertinent experiments throughout the world and has comprehensively analyzed the events of the Three Mile Island (TMI) accident. This code has evolved from development to application almost in coincidence with a corresponding shift in NRC priorities, from less interest in development of large computer codes to greater emphasis on providing direct applications help to an international program with Germany and Japan in LWR safety—involving computer codes, analysis, experimentation, and instrumentation. The need to look at potentially severe LWR accident sequences—with sophisticated codes like TRAC—is apparent, and we are participating in a multilaboratory effort to help NRC better understand these conceptual accident sequences and to identify how they can be prevented or mitigated. We are also performing computer analyses of many other less-severe accident sequences, modeling experiments, and assessing structural problems in reactor systems and containments.

A wide variety of technical assistance projects are also undertaken for NRC by the strong base of experienced engineering talent available at the Laboratory in subjects ranging from safeguards and security to respirator research. These assistance projects pertain to many of the nuclear facilities under NRC jurisdiction, including power reactors, nonpower reactors, and fuel cycle facilities.

A strong effort in the advanced reactor field is continuing with emphasis on the modular reactors. Also, continued development and experimental assessment of the fast-reactor SIMMER code is being supported by the NRC to better understand LMFBR accidents, and the capability to model entire LMFBR accident sequences with a combination of codes, including SIMMER, is the goal. Such studies have already shown that previously used techniques tend to substantially overestimate system damage that could result from a core meltdown accident.

## *OTHER FEDERAL AGENCIES AND OTHER ENTITIES*

### *ADVANCED SPACE REACTORS*

The triagency agreement among DoD, DOE, and NASA on advanced space reactor studies has already been mentioned. NASA will supply certain facilities and some of its considerable expertise in conversion technology as well as part of the funding to this program.

DARPA and DOE will also contribute funding. Based on recent testimony before the House Science and Technology Committee, funding for the SP-100, 100-kWe-class system is anticipated to total \$355 million for the FY 1986-1991 period. However, most of Los Alamos National Laboratory's funding will come from DOE.

### *INTERNATIONAL TECHNOLOGY*

Other (non-DoD) reimbursables sponsors of international technology studies range from the Central Intelligence Agency to Rockwell International. As with DoD reimbursables, the topics of investigation are very dependent upon international events, politics, and technologies and all relate to enhancement of security of the United States.

### *OTHER*

Other research and development, estimated at about \$6.3M in FY 1984, is performed for federal agencies other than DoD and NRC. In addition to those mentioned elsewhere, these agencies include the Departments of Agriculture, Commerce, Interior, Transportation, and Health and Human Services, and the Environmental Protection Agency and the National Science Foundation. Support from non-federal entities, estimated to total about \$9.7M in FY 1984, will be provided by foreign governments such as Germany, Japan, and the United Kingdom, and by domestic entities such as EPRI, universities, states, IBM, TRW, Westinghouse, and others.

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## **VI. SITE AND FACILITIES**

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## VII. SITE AND FACILITIES

### *SITE DEVELOPMENT*

Planning is crucial for the Laboratory today because of the severe shortage of developable land with adequate supporting utility systems, development funds, high construction costs, and keen competition for funding between programs and between National Laboratories. Los Alamos is further constrained by topography, archaeology, and other natural characteristics unique to this site. Most of the Laboratory's major facilities were constructed in the early 1950s and have since become expensive to maintain and reuse. Under current budgetary constraints and because few new construction projects are approved, the Laboratory must invest the resources needed to maintain, upgrade, and expand aging facilities to retain acceptable performance levels for the projects housed within them.

The Laboratory published its first Long-Range Site Development Plan (SDP) in the spring of 1983. Siting and descriptions for all line items and those proposed through 1990 are included in the Five-Year Interim Implementation Plan completed in 1984. The SDP enumerated a list of additional studies that will be necessary as part of the ongoing planning process. Several of these are already complete or very near completion. Included in that category are the Dynamic Testing Division High-Explosives Area Plan, the Weapons Design Engineering Technical Area Plan, the Sanitary Landfill Study, and the Highway and Intersection Location Studies. Additional studies from that list, already under way, include a Long-Range Utilities Plan, Plan Implementation Study, and a Borrow Area Plan.

The Long-Range Facilities Planning Group has also undertaken land use and facilities planning with seven operating divisions to assist in the integration of programmatic planning efforts and facilities planning. Much more effort will be required in this area to complete plans for the remaining operating divisions at the Laboratory.

Finally, to insure adequate oversight and coordination of planning and programming for construction, siting, and the use of Laboratory facilities, a Facilities Review Board has been created.

During the mid-1970s, we began installing leased temporary structures and obtaining commercial leased space in order to alleviate our most critical programmatic space needs. Temporary and commercial leased space now totals about 375,000 ft<sup>2</sup>.

Recent studies place the Government-owned and leased office space utilization rate at Los Alamos at 115 ft<sup>2</sup> per person. This study was performed according to 41 CFR Ch. 101-17 General Services Administration, Assignment and Utilization of Space, which places the national utilization rate goal at 135 ft<sup>2</sup> per person. The Los Alamos utilization rate of 115 ft<sup>2</sup> per person is verification of the crowded conditions and the need for additional space.

Future plans are to decrease temporary, commercial leased, and permanent inadequate space through the acquisition of new permanent facilities and are shown graphically in Fig. VI-1. The average age of facilities is over 25 years and a significant backlog of proposed projects exists to replace and upgrade our aging facilities.

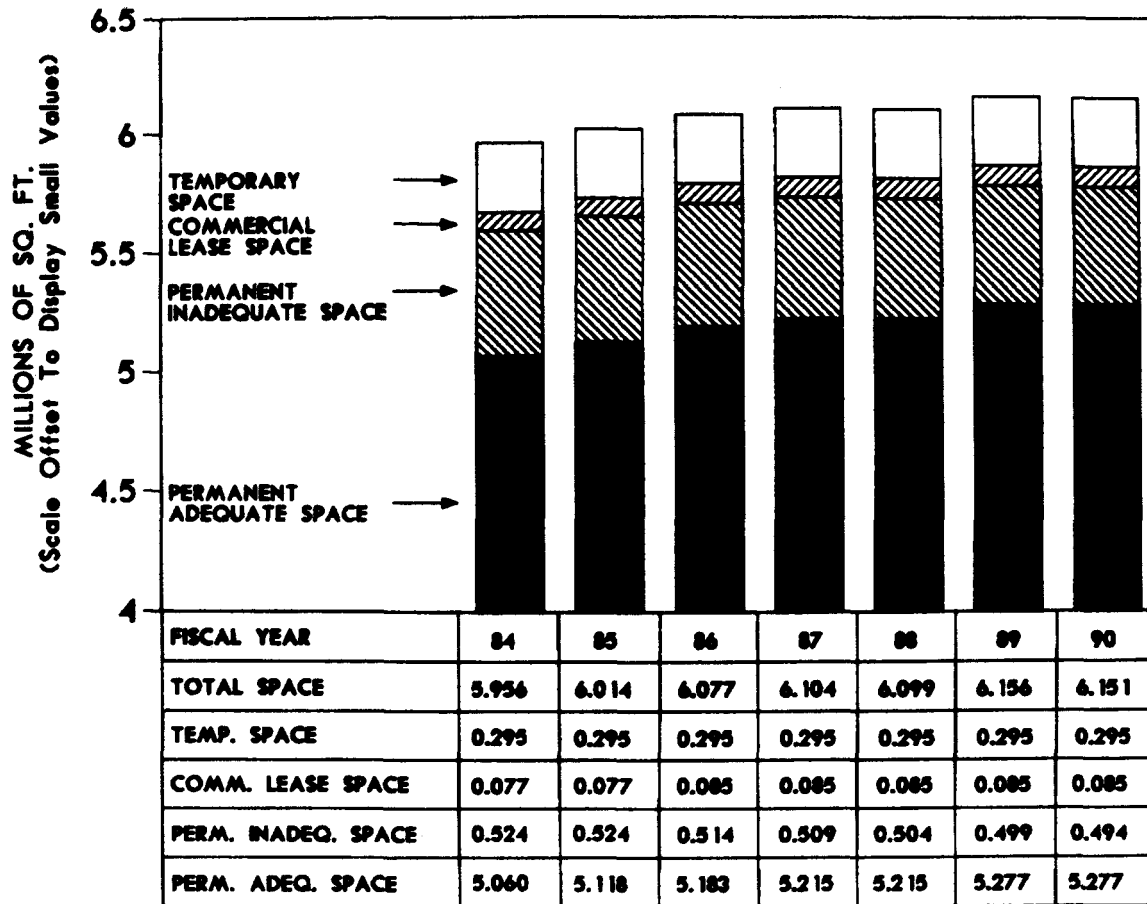


Fig. VI-1 Total Occupied Space

## CONSTRUCTION PROJECTS

### DEFENSE PROGRAMS

#### FUNDED

##### **GB-01—Weapons R,D&T Activities**

*Proton Storage Ring (TEC \$21.8 M, FY79):* The purpose of the PSR is to accumulate large quantities of 800-MeV protons from the LAMPF accelerator and rearrange the time structure of these protons to provide an optimized source for generating neutron bursts at the WNR facility. Protons accumulated in the PSR can be delivered to the WNR target in a sequence of intense, very short (1-ns) pulses or in still higher intensity and longer (270-ns) pulses at a lower repetition rate. The PSR will radically increase the neutron pulse capability of the WNR facility and is expected to provide DOE with a wide-spectrum laboratory pulsed-neutron source that will be unmatched anywhere in the world.

*Upgrading Industrial Liquid Waste Treatment Plants (TEC \$8.0 M, FY81):* The liquid waste treatment plant will be improved to enhance the quality of effluent (new filters, ion-exchange columns, evaporators, storage tanks, and packaging system additions have been installed and are being activated).

*Water Systems Upgrade (TEC \$9.0 M, FY78):* This project includes construction of two new water wells with associated pumps, piping, and storage facilities and replacement of the existing water supervisory control system.

*New Tritium Facility (TEC \$7.1 M, FY82):* This project involves construction of a new facility and installation of process equipment for handling tritium, including design for containment.

*New Detonator Facility (TEC \$18.2 M, FY82):* This complex provides new office, support, and high explosives buildings to replace 40-year-old facilities. The complex supports detonation systems development and production.

*Radioactive Liquid Waste Collection System Improvements (TEC \$12.5 M, FY79):* Abandoned radioactive liquid waste mains and contaminated structures are being removed.”

*Los Alamos Airport Improvements (TEC \$3.1 M, FY83):* The runway will be upgraded and lengthened, and other improvements will be made.

*Nuclear Materials Storage Facility (TEC \$19.3 M, FY84):* This facility will accommodate the nuclear materials recovery and storage demands at the Los Alamos National Laboratory in more secure and safe facilities.

The facility will be used as a repository for storage of source and other nuclear materials. This project is sited adjacent to the Plutonium Facility.

*Central Guard Facility (TEC \$6.2 M, FY84):* This project will contain critical security functions in a hardened environment. It will provide housing for resources that will reduce response time to the majority of the sensitive facilities and will enhance the ability to protect the Laboratory, its communications systems, and other vital functions.

The facility will be a subterranean building providing a hardened environment with a capability of withstanding a light-weapons-fire attack while maintaining the communications, armory, and vault support functions necessary to coordinate other security resources as needed.

*Test Fabrication Facility\* (TEC \$8.0 M, FY84):* This project is to provide for the construction of a new facility to support the NTS Weapons Test Program and to provide for the procurement and installation of special equipment to produce weapons test-rack assemblies.

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\*These projects are a part of the DOE Weapons Test Revitalization Project.

The project includes two test holes with multistory test towers above, a painting facility, a harness fabrication and tensile-testing facility, site work and utilities, and special and standard equipment.

*X-ray Calibration Upgrade\** (TEC \$4.9 M, FY84): This project will provide for the design, procurement, and installation of beam line components at a major synchrotron radiation facility.

It also includes expansion and upgrading of x-ray characterization equipment and facilities at Los Alamos.

This facility will provide a high-intensity, tunable, short-pulse, low-divergence source using an existing synchrotron radiation beam line to meet requirements for increased diagnostic capabilities in the test program.

*Advanced Radiochemical Weapons Diagnostic Facilities\*\** (TEC \$7.8 M, FY85): This project will provide necessary laboratories, laboratory support space, and equipment to support advanced radiochemical diagnostics of weapons tests.

The proposed facilities include two new buildings to be constructed adjacent to the existing Radiochemistry Laboratory Building. The Isotope Separator Building will be constructed to house two isotope separators. A Radiochemistry Laboratory Building will be constructed to provide "clean" laboratory space for mass spectrometers and chemistry as well as standard chemistry laboratories, offices, a stockroom, toilet/change rooms, and facilities equipment space.

### **GB-03—Production and Surveillance**

*Equipment/Utility Restoration* (TEC \$118.3 M, FY82-FY88): This project provides for the restoration and replacement of utilities and laboratory equipment at various locations within the Laboratory that have been identified as poor and/or inadequate.

The utilities include interior building systems such as compressed air, cooling water, heating, ventilating and air conditioning (HVAC) systems and exterior systems such as water, sewer, gas, steam, telephone, electric lines, and power plant systems.

### **GC-01—Verification and Control Technology**

*Space Sciences Laboratory* (TEC \$7.5 M, FY85): The purpose of the proposed project is to provide the facilities for the development, fabrication, assembly, testing, calibration, quality control, and operations associated with our satellite-related activities in the verification programs.

This facility will contain development laboratories, instrumentation systems fabrication and assembly areas, test and calibration areas, drafting and design areas, controlled storage, clean areas, a vacuum laboratory, low-level radioactive source material storage, offices, computer facilities, a data distribution room, a conference area, a library, a machine shop, storage areas, and support facilities.

### **GD-02—Nuclear Materials Safeguards and Security**

*Safeguards and Security Upgrade, Phase I* (TEC \$15.1 M, FY84): This project provides for increased security of classified material and special nuclear material (SNM) and physical plant security at the Laboratory.

Perimeter fencing is required as a security perimeter in some areas where none now exists and as a physical plant protection perimeter in other areas.

Security upgrades consist of enhanced and additional alarm systems and lighting in SNM areas and other areas of security interest.

Back-up power would provide uninterrupted power and emergency generators for the perimeter lighting and alarm systems.

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\*These projects are a part of the DOE Weapons Test Revitalization Project.

\*\*This project is a part of the multi-year, multi-site DOE Weapons R,D&T Revitalization Project.

**BUDGETED****GB-01—Weapons R,D&T Activities**

*Laboratory Data Communications Center (TEC \$28.1 M, FY86):* This project will alleviate rapidly developing space limitations at the Central Computing Facility (CCF) and will provide space for on-site switching for the Laboratory telecommunications system, including its operation and maintenance.

This project is needed to improve significantly the use of the Los Alamos National Laboratory computing resources by providing connectivity to these resources for the entire Los Alamos staff and to provide a facility designed to accommodate computing and communications growth projected for the next two decades.

This facility is a multistory building and will accommodate projected computing and telecommunications growth.

*Special Nuclear Materials R&D Laboratory Replacement (TEC \$210 M, FY86):* This project will replace and refurbish aging laboratories at the Chemistry and Metallurgy Research (CMR) Building and deteriorated equipment and utilities to ensure continued long-term reliable, safe, and secure operation of essential chemistry and metallurgy R&D activities in support of the Laboratory's Plutonium Facility and other national defense programs.

This project will consist of the construction of an SNM R&D Laboratory Building, a Support Building, a Utility Building, all adjacent to the Plutonium Facility, and the decontamination, conversion, and refurbishment of laboratory space in the CMR Building for non-SNM (cold) chemistry use.

*Dual-Axis Radiographic Hydrotest Facility (TEC \$27.2 M, FY86):* This project provides facilities to accommodate the weapons design improvements effort by providing an expanded diagnostic capability that may prevent major program setbacks in a late development stage.

The project provides for the development and procurement of two flash x-ray machines (for dual-axis radiography), procurement and installation of state-of-the-art hydrodiagnostic instrumentation at a new firing site, and construction of a weatherproof radiographic systems development and calibration building.

**GD-02—Nuclear Materials Safeguards and Security**

*Nuclear Safeguards Technology Laboratory (TEC \$14.6 M, FY86):* The purpose of this project is to provide a new facility that will consolidate principal activities of the Nuclear Safeguards R&D Programs and that will support rapid transfer of advanced safeguards technology to the nuclear community and the International Atomic Energy Agency.

This facility will consist of a multistory building and will include space and provisions for accommodating safeguards training courses that are sometimes attended by uncleared personnel and foreign nationals. It will contain electronic instrument development laboratories, training laboratories, a seminar facility, offices, computer facilities, a conference area, a machine shop, a Category I SNM vault, a shielded laboratory, a controlled-testing laboratory, storage areas, and support facilities.

**PROPOSED****GB-01—Weapons R,D&T Activities\***

*Device Fabrication R&D Facility (TEC \$47.0 M, FY87):* This project is to provide at Los Alamos a complete technology-base capability to support the Laboratory's advanced-design nuclear weapons program. This capability will support the development of advanced materials for the nuclear weapons program and the fabrication and assembly of advanced nuclear weapons devices that are tested by the Laboratory. The project will fill numerous technology gaps that have developed at the Laboratory through the past several years because of inadequate capital funds.

\*All proposed projects are a part of the multi-year, multi-site DOE Weapons R,D&T Revitalization Project.

The project is divided into six separate projects that represent six vital areas of material technology supporting the Laboratory's R&D and test program.

*Materials Science Laboratory (TEC \$25.8 M, FY87):* This project will provide needed special laboratory space and facilities for materials science and technology important to the national security programs.

The project includes a multistory laboratory/office building, site work and utilities, intersection improvements at Diamond Drive/Pajarito Road to accommodate the increased traffic, and special and standard equipment.

*Explosive Physics Experimental Facility (TEC \$29.9 M, FY87):* The project will provide the Dynamic Testing Division with increased capacity for high-resolution, state-of-the-art experimentation on the detonation of HE.

This project consists of four separate buildings:

- The Main Experimental Building is a hardened structure for housing explosive firing and safety control equipment.
- The Charge Preparation Annex is a hardened structure for preparation of explosives and explosive assemblies.
- The Diagnostic Development and Analysis Building is a light laboratory shops building for equipment fabrication, maintenance, and testing.
- The Administrative and Technical Support Facility is an office facility.

*Weapons Subsystems Laboratory (TEC \$42.3 M, FY87):* This project will replace two existing facilities in Los Alamos Canyon, plus a gas test facility and a tritium laboratory that are at remote sites. The project will consolidate these remote activities.

Two structures will be constructed: a laboratory building and a laboratory/office building.

*Contained Firing Facility (TEC \$19.2 M, FY88):* This project will provide new facilities that will be suitably configured to take full advantage of recently developed diagnostic techniques. Existing facilities do not allow for precise environmental control and experiment arrangements.

This project will include contained-firing bays, central diagnostic/control room, and an assembly area; firing vessels; a 14,000 sq. ft. addition to an existing office structure; site work and utilities; and special and standard equipment. This project is sited in the HE test area.

*High-Energy Radiographic Facility (TEC \$10.0 M, FY88):* The High-Energy Radiographic Facility will provide high-energy radiographic support to all of the Laboratory's programs except NTS Devices.

A new facility will house existing radiographic machines. The project will also replace the existing 22-MeV Betatron with a new state-of-the-art machine.

*Weapons Component Testing and Development Laboratory (TEC \$13.1 M, FY88):* This facility will allow the Laboratory to meet DOE explosives safety requirements by separating non-HE and HE testing operations. It will consolidate the physical-testing operations now conducted at 3 technical areas and 11 different buildings.

This building will include a high-bay test area, a shop area, laboratory space, a computer room, a low-bay test area, and offices necessary to house the administrative and technical personnel associated with this facility.

*Weapons Containment and Effects Support Facility (TEC \$20.5 M, FY88):* The purpose of the proposed project is to provide the necessary facilities for containment and DOE weapons effects activities in support of the Laboratory's Weapons RD&T Program.

This facility will be a three-story building containing light laboratories, offices, and general support areas.

*Weapons Radiochemistry and Chemistry Laboratory (TEC \$55.5 M, FY89):* This facility will replace an obsolete 40-year-old facility and upgrade capabilities for radiochemical and physical chemistry activities in weapons RD&T.

This facility will contain approximately 100,000 ft<sup>2</sup> of multifunctional space to accommodate radiochemistry and chemistry activities. It will contain laboratories for general-purpose radiochemistry, NTS sample preparation, and development of advanced measurement systems. There will be special complexes for hot-cell operations and clean rooms. There will be an administrative

center for classified computers and secure document storage. Special handling of alpha-active material will be possible. Physical chemistry studies of HE will be conducted. A machine shop will permit mechanical fabrication.

*Weapons Plastics Materials Laboratory (TEC \$16.5 M, FY89):* The purpose of this project is to relocate current plastics operations a safe distance from explosives operations areas, expand capability for large-component fabrication, and increase safety of specific plastics operations.

This project is for a Weapons Plastics Materials Laboratory of approximately 30,000 ft<sup>2</sup>. The upper floor will contain plastics-processing equipment, special formulating laboratories, a solvent operation and spray booth, ultrasonic cleaning, autoclaves, ovens, and similar equipment used in plastics molding, formulating, and fabrication processing.

*Dynamic Testing Complex (TEC \$11.5 M, FY89):* This project will provide much-needed laboratory space and offices to centralize many of the personnel of the Dynamic Testing Division. This will result in better communications and improved coordination within the division.

This project includes a two-story laboratory/office building, partially within the security area and partially outside, site work and utilities, and some equipment.

*Equipment Service Facility (TEC \$4.8 M, FY89):* This project will replace facilities at TA-16 that are approximately 35 years old and in poor condition. Most of the space is occupied by machine tools and leaves little space for equipment repair.

The facility will house instrumentation and mechanical maintenance technicians of the Engineering and Information Resources Group.

*HE Device Environmental Testing Laboratory (TEC \$15.3 M, FY89):* This facility consolidates HE Dynamic and Material Testing Laboratories into one appropriately designed facility separated from intentional detonation areas.

The Dynamic and Material Test Wings and HE Magazine will use blast-resistant construction with blow-out panels, while providing strict environment control. The Test Operations Wing houses data acquisition equipment, mechanical equipment, and limited personnel support areas. Enclosed walkways will connect the separate wings and the magazine.

*Reaction Physics and Materials Research Facility (TEC \$16.1 M, FY90):* This firing site facility will be used for the study of equation of state and dynamic response properties of both inert and reactive materials in experiments requiring HE driving systems and will provide new diagnostic capabilities.

The facility will consist of a multidagnostic firing site, an assembly and support building, and three explosive storage magazines. The facility is to be located in the HE-testing area.

## **GD-02—Nuclear Materials Safeguards and Security**

*Safeguards and Security Upgrade, Phase II (TEC \$14.2 M, FY 88):* This project provides for increased security of classified material and SNM and physical plant security at the Laboratory.

Two control stations will be built. These stations will serve visitor control and identification, general traffic control, and emergency control when needed. A new live-firing range will be constructed.

Special communication will include additional Data Encryption Standards communications along with new antijam radio communication and closed-circuit television surveillance in appropriate security areas. Special vehicles and computer equipment will be purchased.

## *ENERGY RESEARCH*

### *FUNDED*

#### **KB-01—Nuclear Physics**

*Accelerator Improvements (TEC \$0.5 M, FY84; TEC \$1.0 M, FY85):* This is a continuing program to upgrade the A-1 target cell and the A-6 beam-stop area on the main beam line at LAMPF for higher-current capability and improved reliability. The beam-stop area will be significantly modified to accommodate more sophisticated radiation effects studies and to reduce the level of radioactive emissions.

#### **KC-02—Materials Sciences**

*Improvements to Weapons Neutron Research Facility (TEC \$2.7 M, FY83):* This program includes upgrading of the existing WNR facility by modification to the proton beam transport line and installation of additional shielding, cooling, and remote handling equipment.

The existing WNR facility can accommodate a 20-A beam of 800-MeV protons from the Clinton P. Anderson Meson Physics Facility for the production of neutrons. This project improves the WNR to allow use of up to 200 A of protons, permitting a large increase in experiments in the weapons and materials science program areas and allowing some to be done that cannot be successfully performed at existing levels.

### *BUDGETED*

#### **HA-02—Health and Environmental Research**

*Toxic Chemical Containment Facility (TEC \$3.0 M, FY86):* This project will provide laboratory space that will be in compliance with federal regulations controlling the use of toxic chemicals and will provide space not currently available at the Laboratory.

This project provides for a special laboratory for handling toxic chemicals to be used for experimenting with cellular and animal systems.

### *PROPOSED*

#### **HA-02—Health and Environmental Research**

*Life Science Research Building (TEC \$29.3 M, FY87):* The purpose of the proposed project is to improve and expand the following facilities in the Life Sciences Division: Animal Facilities, Flow Cytometry, Nuclear Magnetic Resonance, Electron Microscopy, Cell Tissue Culture, Radiation Biology, and Environmental Science.

This facility will consist of a flexible, change-responsive, R&D laboratory/office building including space required for accreditable animal research facilities. It will contain chemistry laboratories, biologic and tissue culture laboratories, histology and general-purpose laboratories, surgery and microscopy rooms, x-ray and darkrooms, offices, computer facilities, conference areas and library, rack-washing and sterilization areas, a greenhouse, storage areas, and support facilities.

**KC-02—Materials Sciences**

*Neutron-Scattering Experimental Halls (TEC \$18.8 M, FY87):* The construction associated with this enhancement of the WNR facility will provide an experimental hall to the east of the existing WNR experimental area, a support building adjacent to the east experimental hall, improvements to the existing experimental area, and the site work necessary to support these new structures.

The experimental hall will be an 18,000-ft<sup>2</sup> pre-engineered high-bay structure on a concrete slab attached to the east side of the WNR facility. This structure will house a minimum of nine experiments and will provide a staging area for servicing these experiments and building new ones. A 17,500-ft<sup>2</sup> laboratory and support complex will be located adjacent to the experimental hall for easy access between the experimental facilities and data collection, shops, and other support services. The completed facility will support a national DOE-sponsored user program for condensed matter research based on advanced pulsed-neutron-scattering techniques.

## *MANAGEMENT AND ADMINISTRATION*

### *BUDGETED*

#### **WB-00—In-House Energy Management**

*Solid Waste Fired Boiler Facility (TEC \$7.6 M, FY86)*: This facility will use heat recovery to provide heating and process steam to about 65 Laboratory buildings while reducing the volume of Laboratory and municipal refuse by about 90%.

The facility houses central utility function, boilers, and related process equipment to replace a 32-year-old steam plant. This project is sited near the present steam plant.

### *PROPOSED*

#### **KG-00—Roads and Utilities Capability Upgrade**

*Pajarito Hill Road Improvements (TEC \$3.0 M, FY87)*: This project consists of a one-mile-long reconstruction, realignment, widening to four lanes, and upgrading of part of Pajarito Road and the relocation of its two included intersections with access roads to four technical areas. It is needed because this road section has been identified as having a high accident rate, and a potential for involving delivery vehicles carrying radioactive source material, low-level radioactive solid waste, or high explosives to these sites. Few Laboratory roads meet current New Mexico State Highway Department safety and circulation standards.

*Main Tech Area Loop and Bypass Roads (TEC \$16.0 M, FY87)*: Three major roads currently pass through or terminate in the Main Technical Area (TA-3) creating major conflicts between local and through traffic where 75% of the Laboratory employees reside. Rush hours resemble major metropolitan area traffic jams. This project will implement key land use, security, utilities, and transportation elements of the Laboratory's Long-Range Site Development Plan. Compliance with the enhanced security requirements is not possible without this project.

#### **WB-00—In-House Energy Management**

*Sigma Building Heat Recovery (TEC \$1.4 M, FY86)*: This project provides for building modifications that will reduce the energy consumption by about 60% and will comply with the Government's policy to reduce the use of natural gas and petroleum products in DOE facilities.

The project provides for the following energy conservation modifications to the Sigma Building: exhaust-air heat recovery, variable-speed drives, and new and modified HVAC controls.

TABLE VI-1. Major Construction Projects

(\$ in millions)	TEC	FY 1984		FY 1985		FY 1986		FY 1987		FY 1988		FY 1989		FY 1990		AFTER FY 1990	
		BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
<b>FUNDED CONSTRUCTION PROJECTS</b>																	
<b>ASDP</b>																	
<u>GB-01 - Weapons R&amp;D Activities</u>																	
Proton Storage Ring	21.8		6.0		1.5												
Upgrad Indus Liq Waste Treat Plants	8.0		1.3		0.2												
Water Systems Upgrade	9.0		1.2		0.6												
New Tritium Facility	7.1		1.5		0.4												
New Detonator Facility	18.2	3.9	5.0		1.5												
Rad Liq Waste Collect Sys Improve	12.5	3.5	1.1		2.5												
L. A. Airport Improvements	3.1	3.1	2.8		0.2												
Nuclear Materials Storage Facil	19.3	0.7	0.2	6.5	6.8	12.1	8.5		3.8								
Central Guard Facility	6.2	0.6	0.1	5.6	4.2		1.9										
Test Fabrication Facility	8.0	2.5	0.3	5.5	4.7		3.0										
X-Ray Calibration Capacity Upgrade	4.9	1.3	0.5	3.6	2.2		2.0		0.2								
Advanced Radiochemical Diag. Fac.	7.8			1.8	0.8	6.0	4.0		2.9								0.1
Subtotal GB-01	125.9	15.6	20.1	23.0	25.6	18.1	19.4		6.9								0.1
<u>GB-03 - Production and Surveillance</u>																	
Equipment/Utility Restoration	118.3	15.1	15.1	16.6	16.6	20.2	20.2	24.8	24.8	14.6	14.6						
<u>GC-01 - Verif &amp; Control Technology</u>																	
Space Sciences Laboratory	7.5			1.0	0.6	5.5	3.3	1.0	3.5								0.1
<u>GD-02 - Nuc Mat Safeguards &amp; Security</u>																	
Safeg'ds & Security Upgrade (Ph I)	15.1			7.6	7.6	7.5	7.5										
TOTAL ASDP	266.8	30.7	35.2	48.2	50.4	51.3	50.4	25.8	35.2	14.6	14.8						
<b>OER</b>																	
<u>KB-01 - Nuclear Physics</u>																	
Accelerator Improvements (84)	0.5	0.5	0.5														
Accelerator Improvements (85)	1.0			1.0	0.2		0.8										
Subtotal KB-01	1.5	0.5	0.5	1.0	0.2		0.8										
<u>KC-02 - Materials Sciences</u>																	
Improvements to WNR	2.7		1.8		0.2												
TOTAL OER	4.2	0.5	2.3	1.0	0.4		0.8										
<b>TOTAL FUNDED CONSTRUCTION</b>	<b>271.0</b>	<b>31.2</b>	<b>37.5</b>	<b>49.2</b>	<b>50.8</b>	<b>51.3</b>	<b>51.2</b>	<b>25.8</b>	<b>35.2</b>	<b>14.6</b>	<b>14.8</b>						

TABLE VI-1. (cont)

(\$ in millions)	TEC	FY 1984		FY 1985		FY 1986		FY 1987		FY 1988		FY 1989		FY 1990		AFTER FY 1990	
		BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
<b>BUDGETED CONSTRUCTION PROJECTS</b>																	
<b>ASDP</b>																	
<u>GB-01 - Weapons R&amp;D Activities</u>																	
Lab Data Communications Center	28.1					5.0	3.6	21.5	10.6	1.6	13.5		0.4				
SNM R&D Laboratory Replacement	210.0					10.0	6.4	60.0	56.8	55.0	50.4	50.0	42.0	20.0	21.0	15.0	33.4
Dual-Axis Radiographic Hydrotest Fac	27.2					3.0	1.5	24.2	17.6		7.7		0.4				
Subtotal GB-01	265.3					18.0	11.5	105.7	85.0	56.6	71.6	50.0	42.8	20.0	21.0	15.0	33.4
<u>GD-02 - Nuc Mat Safeguards &amp; Security</u>																	
Nuclear Safeguards Technology Lab	14.6					2.9	1.2	11.7	5.1		7.1		1.2				
TOTAL ASDP	279.9					20.9	12.7	117.4	90.1	56.6	78.7	50.0	44.0	20.0	21.0	15.0	33.4
<b>OER</b>																	
<u>HA-02 - Health and Environmental Research</u>																	
Toxic Chemical Containment Facility	3.0					0.3	0.2	2.7	2.3		0.5						
TOTAL OER	3.0					0.3	0.2	2.7	2.3		0.5						
<b>MANAGEMENT AND ADMINISTRATION</b>																	
<u>WB-00 - In-House Energy Management</u>																	
Solid Waste Fired Boiler Facility	7.6					1.8	0.7	5.8	6.8		0.1						
<b>TOTAL BUDGETED CONSTRUCTION</b>	290.5					23.0	13.6	125.9	99.2	56.6	79.3	50.0	44.0	20.0	21.0	15.0	33.4

TABLE VI-1. (cont)

(\$ in millions)	TEC	FY 1984		FY 1985		FY 1986		FY 1987		FY 1988		FY 1989		FY 1990		AFTER FY 1990	
		BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
<b>PROPOSED CONSTRUCTION PROJECTS</b>																	
<b>ASDP</b>																	
<b>GB-01 - Weapons R&amp;D Activities</b>																	
Device Fabrication R&D Facility	47.0							9.5	8.5	22.5	22.0	15.0	15.0			1.5	
Materials Science Laboratory	25.8							3.6	1.7	19.6	8.2	2.6	10.9				
Explosive Physics Exp. Facility	29.9							7.3	2.4	16.8	12.2	5.8	15.0			0.3	
Weapons Subsystems Laboratory	42.3							3.6	1.8	16.3	5.6	22.4	27.7			7.2	
Contained Firing Facility	19.2									2.0	1.0	17.2	12.0			6.2	
High-Energy Radiographic Facility	10.0									4.0	3.0	6.0	5.0			2.0	
Weapons Component Test & Dev. Lab.	13.1									2.0	1.0	11.1	10.0			2.1	
Weapons Cont. & Effects Sup. Fac.	20.5									2.0	1.0	18.5	11.0			8.5	
Weapons Rad Chem & Chemistry Lab	55.5											5.0	2.5	50.5	19.0		34.0
Weapons Plastics Materials Lab	16.5											2.0	1.0	14.5	5.0		10.5
Dynamic Testing Complex	11.5											1.0	0.5	10.5	2.0		9.0
Equipment Service Facility	4.8											4.8	2.0			2.8	
HE Device Environ. Testing Lab	15.3											2.0	1.0	13.3	8.0		6.3
Reaction Phys. & Mat. Research Fac.	16.1													2.0	0.5	14.1	15.6
Subtotal GB-01	327.5							24.0	14.4	85.2	54.0	113.4	113.6	90.8	65.1	14.1	75.4
<b>GD-02 - Nuc Mat Safeguards &amp; Security</b>																	
Safeg'ds & Security Upgrade (Ph II)	14.2									7.5	2.0	6.7	6.0		6.2		
TOTAL ASDP	341.7							24.0	14.4	92.7	56.0	120.1	119.6	90.8	71.3	14.1	75.4
<b>OER</b>																	
<b>HA-02 - Health and Environmental Research</b>																	
Life Science Research Building	29.3							2.5	2.1	22.5	7.5		11.1	4.3	6.4		2.2
<b>KC-02 - Materials Sciences</b>																	
Neutron Scattering Experimental Halls	18.8							10.0	8.0	8.8	10.8						
TOTAL OER	48.1							12.5	10.1	31.3	18.3		11.1	4.3	6.4		2.2

TABLE VI-1. (cont)

(\$ in millions)	TEC	FY 1984		FY 1985		FY 1986		FY 1987		FY 1988		FY 1989		FY 1990		AFTER FY 1990	
		BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
<u>MANAGEMENT AND ADMINISTRATION</u>																	
<u>KG-00 - Roads and Util. Capability Upgrade</u>																	
Pajarito Hill Road Improvements	3.0							3.0									
Main Tech Area Loop & Bypass Roads	16.0							2.5		7.51		6.0					
Subtotal KG-00	19.0							5.5		7.5		6.0					
<u>WB-00 - In-House Energy Management</u>																	
Sigma Building Heat Recovery	1.4							1.4	0.1		1.3						
TOTAL MANAGEMENT AND ADMINISTRATION	20.4							6.9	0.1	7.5	1.3	6.0					
TOTAL PROPOSED CONSTRUCTION	410.2							43.4	24.6	131.5	75.6	126.1	130.7	95.1	77.7	14.1	77.6
TOTAL DOE CONSTRUCTION	971.7	31.2	37.5	49.2	50.8	74.3	64.8	195.1	159.0	202.7	169.7	176.1	174.7	115.1	98.7	29.1	111.0
<u>NON-DOE PROJECTS</u>																	
<u>PROPOSED CONSTRUCTION</u>																	
<u>Defense Advanced Research Projects</u>																	
<u>Agency (DARPA)</u>																	
Free Electron Laser	216.5							3.2	2.8	19.5	18.5	65.0	55.0	96.3	94.0	32.5	46.2
<u>US Army, BMD</u>																	
Accelerator Test Stand Upgrade	111.0			4.0	4.0	38.0	35.0	25.0	25.0	26.0	27.0	18.0	20.0				
TOTAL NON-DOE PROPOSED CONSTRUCTION	327.5			4.0	4.0	38.0	35.0	28.2	27.8	45.5	45.5	83.0	75.0	96.3	94.0	32.5	46.2
GRAND TOTAL																	
ALL LINE ITEM CONSTRUCTION	1299.2	31.2	37.5	53.2	54.8	112.3	99.8	223.3	186.8	248.2	215.2	259.1	249.7	211.4	192.7	61.6	157.2

## GENERAL PLANT PROJECTS (GPP)

The Los Alamos National Laboratory has a continuing need for General Plant funds (Fig. VI-2) in order (1) to implement changes and additions to facilities required because of expanded or changed programmatic goals or to meet new standards established by DOE and others and (2) to replace units of plant nature in order to maintain or to improve upon existing levels of plant efficiency. Included in the first category are improvements, alterations, and additions to existing facilities such as buildings, building service equipment, utilities, roads, and new construction of a minor nature. Plant replacement, the second category, occurs as individual units of plant equipment, building services, and utilities wear out, are rendered hazardous because of contamination, or become obsolete.

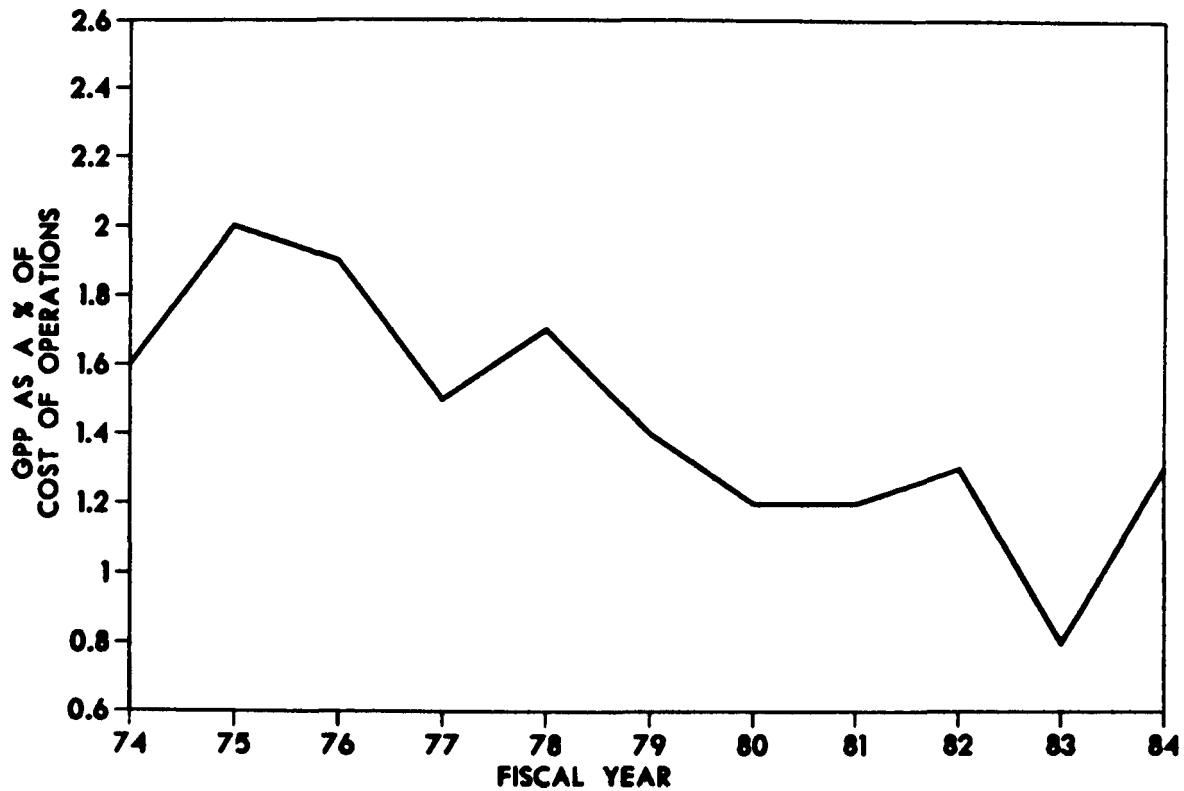


Fig. VI-2. General Plant Projects vs. Cost of Operations

A lack of GPP funding can prevent space and utilities from being improved in a timely manner to keep pace with program requirements, thus reducing the capabilities and efficiency of operations.

Underfunding in GPP also results in the consumption of capital plant through the uneconomical deferral of repairs, which ultimately results in requirements for major replacements later. GPP funding has not kept abreast of the value of the physical plant as seen in Fig. VI-3. The requirement for GPP funding is also affected by the increased aging of the physical plant.

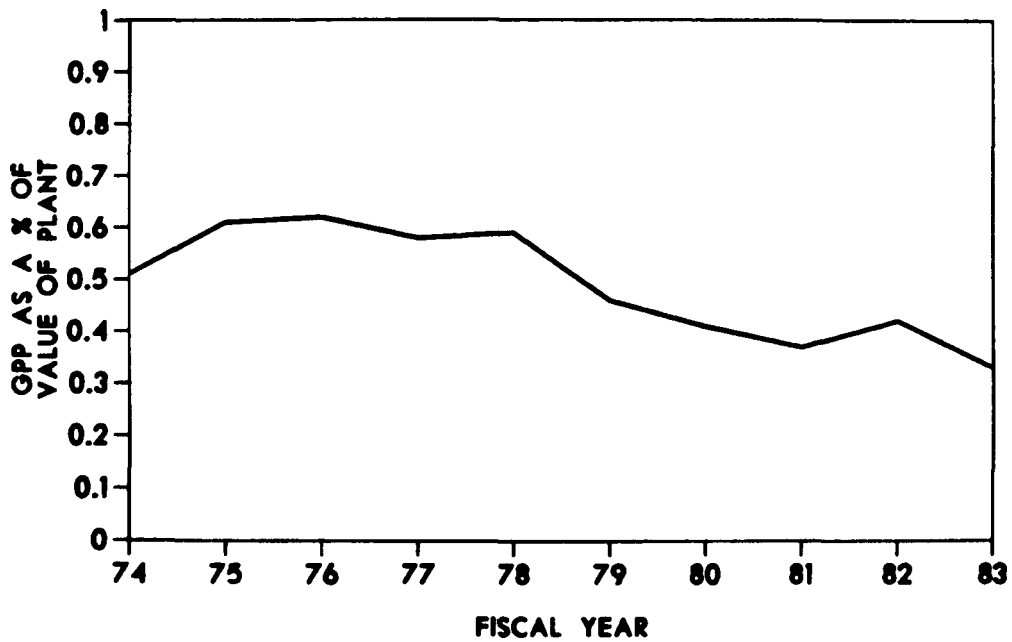


Fig. VI-3. General Plant Projects vs. Value of Plant

The need for increased GPP funding support is obvious from the foregoing discussion. Our internal requests for projects in this funding category for FY 1986 were over \$30 million. The funding projections shown in Fig. VI-4 will relieve the backlog and correct the funding deficiencies stated above. Table VI-2 provides detailed projection of the GPP activity for the Laboratory through FY 1990.

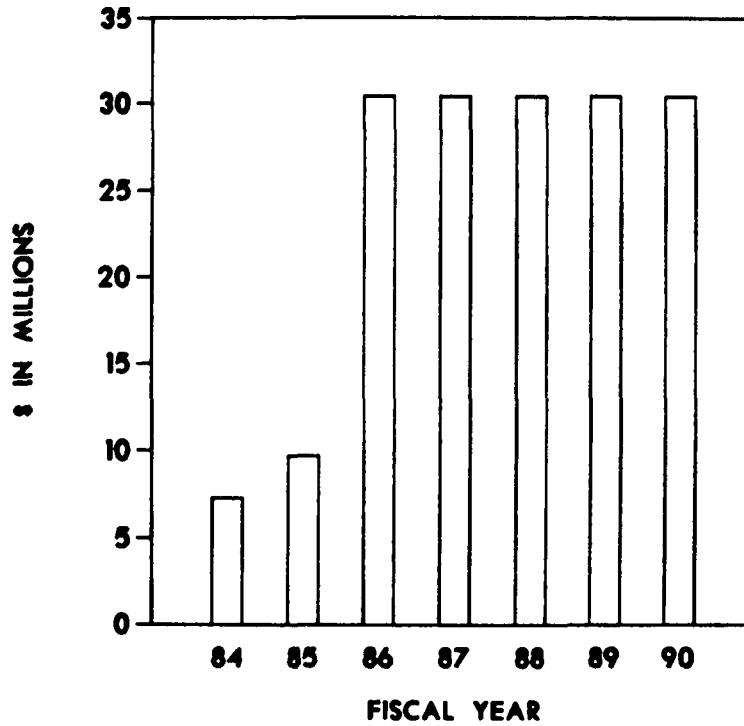


Fig. VI-4. General Plant Projects

TABLE VI-2. General Plant Projects (Dollars in Millions)

		FY 1984	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990
		BA	BA	Requested	Planned	Planned	Planned	Planned
<b>ASDP</b>								
AR-OA	Defense Waste Management	0.4	0.3	0.6	0.6	0.6	0.6	0.6
GB-01	Weapons Activities	5.0	6.3	20.0	20.0	20.0	20.0	20.0
GB-03	Production & Surv.			1.8	1.8	1.8	1.8	1.8
GD-00	Nuclear Materials S&S			0.8	0.8	0.8	0.8	0.8
GE-03	Materials Production	0.9		1.9	1.9	1.9	1.9	1.9
GC	V&CT	6.3	6.6	0.3	0.3	0.3	0.3	0.3
	Subtotal ASDP	6.3	6.6	25.4	25.4	25.4	25.4	25.4
<b>OER</b>								
AT-20	Magnetic Fusion	0.3	0.3	2.1	2.1	2.1	2.1	2.1
HA-02	Environ. R&D/LSR	0.2	0.3	0.5	0.5	0.5	0.5	0.5
KB-01	Nuclear Physics	0.5	1.0	1.2	1.2	1.2	1.2	1.2
AE	Advanced Nuclear Systems			1.2	1.2	1.2	1.2	1.2
	Subtotal OER	1.0	1.6	5.0	5.0	5.0	5.0	5.0
	Total	7.3	8.2	30.4	30.4	30.4	30.4	30.4

## *FACILITIES MAINTENANCE*

The total allocation for maintenance of Los Alamos National Laboratory for FY 1984 is \$23.426 million. Of this amount, \$2.886 million is management, engineering design and inspection, and other technical support, and \$20.55 million is allocated as maintenance funds to be contracted to The Zia Company and other contractors. The \$20.55 million is an increase of approximately 7% over the final FY 1983 allocation for contracted services. Table VI-3 is from the FY 1984 Annual Work Plan and Budgetary Information document that delineates the breakdown of maintenance funds by Functional Categories.

It is anticipated that the maintenance requirements of new facilities should be minimal, but with the effective new technologies being introduced into HVAC and other systems, it is necessary that new maintenance initiatives such as computerized diagnostics and remote equipment surveillance systems not only continue but increase. The Facilities Engineering Division in concert with The Zia Company has established a Facilities Management System Committee charged with the responsibility of searching for and recommending a computer-based facilities management system to meet the needs of the Laboratory. The system will be designed to integrate facility, equipment, work order, and accounting data into one common data base so that management can selectively retrieve "real-time" information on which to base decisions.

The Backlog of Maintenance and Repair (BMAR) was reduced approximately \$1.5 million in FY 1983. The new BMAR for FY 1984 totalled \$10.03 million and will be reduced to approximately \$8 million by FY 1984 ending. The substantial BMAR for FY 1984 beginning is a result of (1) emphasis being placed upon upgrading the condition and physical appearance of buildings and (2) new initiatives regarding the maintenance of lightning protection and emergency lighting systems.

Anticipated funding requirements for FY 1985 through FY 1990 are included in Table VI-4 and Fig. VI-5.

TABLE VI-3. Annual Work Plan FY 1984 - Budgetary Information

Operating Expenses for Maintenance and Repair of Real Property

	Thousands \$
1. In-house work effort (FTEs)	(50)
dollars	\$ 2,886
2. Maintenance contracted to The Zia Company	19,940
3. Maintenance contracted to other	610
Maintenance Total	<u>\$23,436</u>

Functional Categories of Real Property Maintenance and Repair

1. Custodial Services	\$ 7,950
2. Waste Removal Services	250
3. Fire Detection and Suppression Systems	965
4. Snow Removal	430
5. Building	1,766
6. Mechanical	3,651
7. Electrical	1,588
8. Roads & Parking Areas	1,029
9. Grounds	718
10. Roofs	508
11. Miscellaneous	1,695
12. Management ED&I and other technical support	2,886
Total	<u>\$23,436</u>

Supporting Information for Real Property Maintenance and Equipment Replacement

1. GPP	\$ 500
2. Weapons Utility Restoration	\$ 3,590

TABLE VI-4. Long-Range Work Plan<sup>a</sup>

	Anticipated Funding Requirements (in thousands of FY 1984 dollars)					
	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990
Base Maintenance	\$18,764	\$18,985	\$19,377	\$20,498	\$21,013	\$21,433
Backlog Reduction	1,500	1,500	1,500	1,500	1,500	1,500
New Maintenance Requirements	<u>800</u>	<u>800</u>	<u>800</u>	<u>200</u>	<u>200</u>	<u>200</u>
TOTAL	\$21,064	\$21,285	\$21,677	\$22,198	\$22,713	\$23,133

<sup>a</sup>Total anticipated funding requirements for FY 1985 through FY 1990 were derived from projected plant growth and new maintenance incentives.

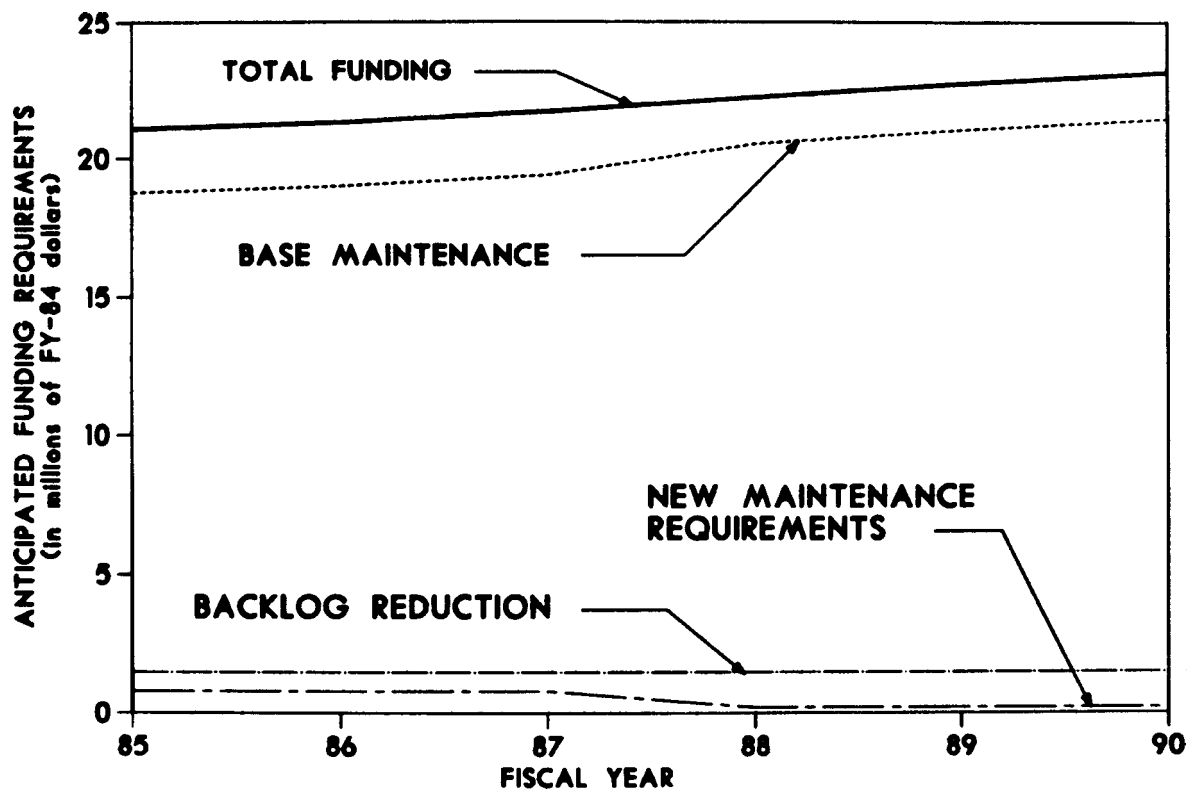


Fig. VI-5. Anticipated Maintenance Funding Requirements

## *AUTOMATED DATA-PROCESSING EQUIPMENT (ADPE) REQUIREMENTS*

The Laboratory's historic emphasis on computing is motivated primarily by the needs of national defense, energy, and basic research programs. Starting at the birth of electronic computation shortly after World War II, Los Alamos has operated one of the world's largest computing facilities and continues to be at the forefront of scientific computing. Defense programs are the heaviest users of the total computing resources (see Fig. VI-6); DOE and DoD programs gain important military, technical, and economic advantages by providing supercomputers to Los Alamos and other national programs. These advantages include

- the development of superior-quality products for the DOE and DoD,
- the ability to perform advanced development and research projects that could not otherwise be attempted,
- significant reductions in the development costs of these products, and
- significant reductions in the time needed to develop these products.

If the nuclear weapons currently under development are compared with those of 10 years ago, it is clear that modern weapons technology is far superior in terms of meeting today's national defense needs. A large share of this advance is due to the steady improvement in the capabilities of the computing resources available to weapons designers. Ultimately, it is the ability to model theoretically and to calculate accurately that determines the quality of our nuclear weapons stockpile. This, in turn, is governed by the quality and quantity of computing resources available. In a similar manner, computing is crucial not only to the Laboratory's defense programs but to virtually all of the Laboratory's R&D programs.

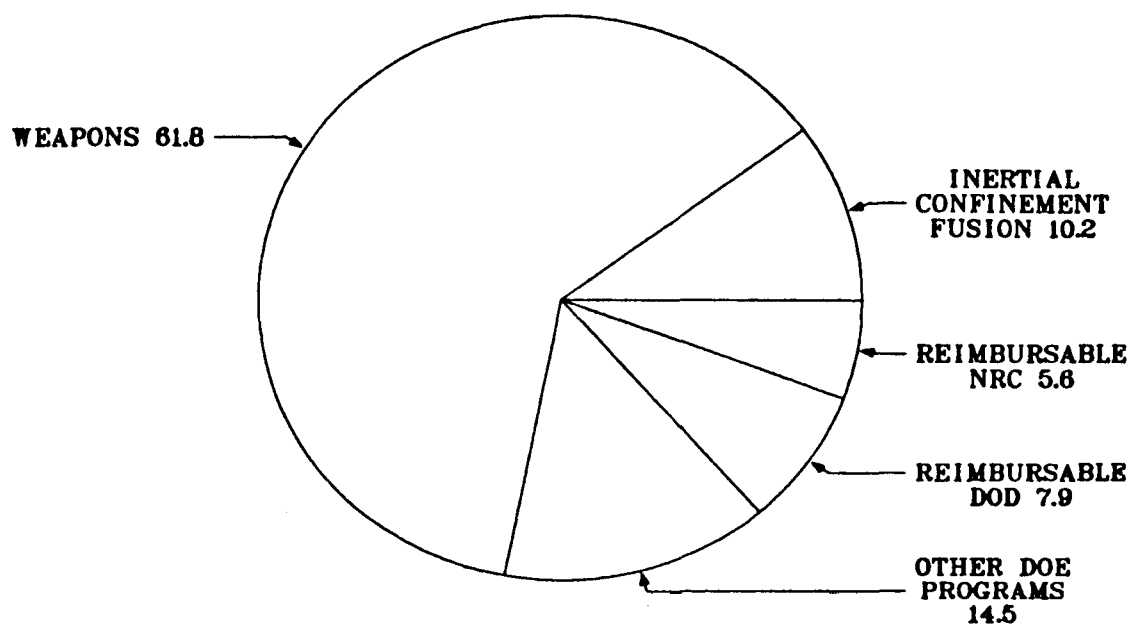


Fig. VI-6. Distribution of Computing by Program (%)  
FY 1984 (Oct.-Apr.)

Los Alamos also provides computing services for other national programs such as DNA and NRC on a noninterference basis with DOE programs. In providing these services, Los Alamos will help satisfy the national need for supercomputer services as pointed out by the National Science Foundation/DoD Lax Panel Report. In supporting other national programs, the Laboratory also seeks to improve the synergy between its programs and others, find more collaborative scientific work, and help create a large pool of scientists and engineers trained in the use and support of supercomputers.

The most powerful of the Laboratory's computers is the Cray Research, Inc., (CRI) Cray X-MP. Other major worker computers include four CRI Cray-1 systems and four Control Data Corporation (CDC) 7600 systems. The Laboratory also operates a CDC Cyber 176 computer for the DNA to serve about 800 users nationwide. These machines are located in the CCF, which also houses a number of smaller computers and three supporting subsystems: the Common File System, the Print and Graphics Express Station, and the Facility for Operations Control and Utilization Statistics.

All of the large Los Alamos computers are connected through an extensive data communications network to an Integrated Computing Network. The network supports over 150 computer systems, including both the large supercomputers at the CCF and the remote multiuser systems called distributed processors. It provides complete interactive and batch services to almost 6,000 computer users and allows rapid access to the major computers and other systems while minimizing duplication of resources. We support many different types of terminals including intelligent workstations, high-resolution color graphics terminals, and portable keyboard devices for dial-up use. The network is divided into three partitions: Secure, for classified computing; Administrative, for processing of sensitive data; and Open, for unclassified scientific and nonsensitive administrative activities.

Space needed to house both people and computing equipment is in very short supply. Construction of the Laboratory Data Communications Center (a proposed FY 1986 construction project) will allow the Laboratory to install the computers that are needed to meet our programmatic requirements as well as to expand the data communications network to accommodate its rapidly increasing number of users. The new building will also house the Laboratory's telecommunications system.

Plans for the acquisition of computers and their necessary support and peripheral equipment are detailed in the Los Alamos input to the DOE ADP Long-Range Plan. Significant items in that plan are summarized in Table VI-5.

The table indicates that additional major scientific computers will be acquired in each fiscal year through FY 1990. The Cray X-MP is a multiprocessor, Class VI machine. Our first Class VII computer is forecast to arrive in FY 1986. "Class VII" is used to describe a system that is, at the very least, four times as powerful as a Class VI computer.

One of our four Cray-1s is listed in Table VI-5 because of lease expenditures during the period covered by the table. A fifth Cray-1 will be added in FY 1985. The line item labeled Administrative Computers addresses the upgrade of obsolescent processors in the Administrative partition of the network.

The item labeled Mass Storage Upgrade identifies enhancements of the Laboratory's Common File System. This data storage facility serves the entire network; its capacity must grow as additional computing power is provided, and its bandwidth must be increased to avoid degradation in the speed with which data can be accessed.

Another network resource that must keep pace with network processing power is the Print and Graphics Express Station, which processes the printed and graphical output generated by the computers. Plans for its enhancement appear in the table as Output Station Upgrades.

Interactive Graphics for CAD/CAM, a line item that appears in the FY 1985 through FY 1990 columns of the table, deals with equipment that will support conceptual and engineering design and manufacture of more complicated weapon components.

TABLE VI-5. Los Alamos National Laboratory Major ADP Leases and Purchases (\$K)		FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990
CRAY-1 (3rd)	(LEASE)	(3400)	(3400)	(600)			
CRAY X-MP (1st)	(LEASE)	(4000)	(4000)	(4000)	(660)		
CRAY X-MP (2nd)	PURCHASE (LEASE)	(5600)	15200 (930)				
CRAY-1 (85U)	(LEASE)	(1950)	(2600)	(1300)			
CLASS VII COMPUTER (86C)	PURCHASE (LEASE)		(2600)	(5200)	12600 (870)		
CLASS VII COMPUTER (87U)	(LEASE)			(2250)	(4500)	(4500)	(4500)
CLASS VII COMPUTER (88C)	PURCHASE (LEASE)				(2600)	(5200)	12600 (870)
CLASS VII COMPUTER (89U)	(LEASE)					(2250)	(4500)
CLASS VIII COMPUTER (90C)	(LEASE)						(2600)
ADMINISTRATIVE COMPUTERS	PURCHASE (LEASE)	710 (95)					
MASS STORAGE UPGRADES	PURCHASE		4200		4000		3000
OUTPUT STATION UPGRADES	PURCHASE	1500			1500		
INTERACTIVE GRAPHICS FOR CAD/CAM	PURCHASE	4000	2900	4800	4000	3700	3000

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## **VII. EXTERNAL INTERACTIONS**

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## VII. EXTERNAL INTERACTIONS

### *INDUSTRIAL INITIATIVES*

#### *OVERVIEW*

The Laboratory's industrial initiatives have both external and internal goals. On a national scale, the external goals are to help effect the optimum use of Laboratory technology by industry in order to contribute to the Nation's industrial strength and to strengthen the Laboratory's science and technology base. The regional goal is to provide appropriate technical assistance to state government, private industry, and other regional entities.

The internal goals are to strengthen the value of the Laboratory's applied programs through early and sustained collaboration with the ultimate developers and suppliers of the resulting technology and to enhance the scientific, technical, and managerial vitality of the staff through collaboration with industry and others.

In content, this program is part of a larger effort to develop a full range of collaboration in both applied (typically energy-related) programs and in the basic sciences and underlying technology areas.

The professionals responsible for the industrial initiatives functions report to the Assistant Director for Industrial & International Initiatives. Because the technical resources for these functions are spread throughout the Laboratory, there are formal lines of communication with virtually every level of management in both discipline and program, weapons and nonweapons areas. There is specifically assigned legal support for this function in the Patent Law Division.

On January 3, 1983, the Laboratory issued the "Revised Report of the Laboratory-Industry Technology Initiatives Committee." This presents background perspectives and recommended initiatives based on the Laboratory's goals in the industry part of technology transfer. The report represents an important effort by the Laboratory and is an indication of its support for this activity.

#### *PROCESS*

The Technology Transfer Program uses a five-part process to develop the supply, demand, and execution of appropriate transfers to industry:

*Industry Liaisons.* To establish beneficial liaisons with industry, the strategy is to work simultaneously on development of Laboratory interests, industry contacts, and methods for cooperation, and on identification and reduction of barriers. Companies are targeted nationwide to develop liaisons in both technology and programmatic areas, typically through invited visits with planned personal follow-up in specific technical areas. Work with small businesses is focused regionally, with particular attention to cooperation with the University of New Mexico's Technical Innovation Center, existing small businesses, and interest in the spin-off of companies locally to exploit Laboratory technology.

*Federal Laboratory Consortium (FLC) Use.* Through active participation in the FLC network, the Laboratory is able to draw upon the unique expertise of other federal laboratories in addressing requests for assistance and is conversely a resource to entities outside its geographical region.

*Information Development.* Although most "information dissemination" is passive and yields little direct technology transfer, it can have an important role in establishing personal contacts from which productive transfer can result. Information targeted directly to potential users

(for example, trade journal articles and distribution of applications assessments) have particular emphasis; professional publications, press releases, and the magazine *Los Alamos Science* also have an important role.

*Internal Laboratory Motivation.* The Laboratory must develop motivation and interest within the Laboratory's staff and management in technology-transfer-related activities; institute an ongoing inventory of new ideas, technologies, and research results for review and transfer; and provide an environment that encourages working-level staff to propose and pursue technical initiatives with industry.

*Individual Entrepreneurship.* A growing body of local interest and experience and national policy is strengthening significantly the role of individual entrepreneurs in commercial applications of Laboratory technology.

### *ESTIMATED RESOURCES: PERSONNEL AND FUNDING*

<u>Funding</u>	<u>FY 1984</u>	<u>FY 1985</u>	<u>FY 1986</u>	<u>FY 1987</u>	<u>FY 1988</u>	<u>FY 1989</u>	<u>FY 1990</u>
(\$ in thousands)							
Industrial Init.	300	300	300	300	300	300	300
Other (estimate)	5200	5200	5200	5200	5200	5200	5200
Total	5500	5500	5500	5500	5500	5500	5500
<u>Staffing</u>							
(in FTEs)							
Professional Staff							
Industrial Init.	2	2	2	2	2	2	2
Other	20	20	20	20	20	20	20
Total	22	22	22	22	22	22	22
Support Staff							
Industrial Init.	1	1	1	1	1	1	1
Other	10	10	10	10	10	10	10
Total	11	11	11	11	11	11	11

### *SMALL BUSINESS*

The Laboratory has begun to encourage actively entrepreneurial approaches to practical applications of its technology:

- A monthly Innovators' Forum exposes interested members of the Laboratory's staff and others from the local area to the business side of technical entrepreneurship, including venture capital, marketing, patents, and business planning.
- Laboratory cooperation with the University of New Mexico's Technological Innovation Center includes sponsorship of courses in entrepreneurship at the Los Alamos Graduate Center.
- Two Laboratory technologies have formed the basis of SBIR grant awards, one of which is in phase 2.

- A small laser company, PSI, received a million-dollar venture capital commitment to commercialize a laser device invented at the Laboratory but developed privately.
- The Laboratory cosponsored a workshop on “small-business incubator” facilities, largely to spur the development of an incubator in the local community.
- Approximately 200 members of the Laboratory’s staff work also as private consultants, as encouraged by DOE policy and approved by Laboratory management.

## *LARGE INDUSTRY*

Through several channels, the Laboratory has begun collaborations with the large American companies:

- Industrial Staff Member agreements have been concluded recently with 3M, Arco-Silag, and SCRIPCO (formerly Carborundum).
- Industrial-sponsored programs at the Laboratory have been undertaken when they provide substantive benefits to the Laboratory’s core technology base and to DOE programs. Such programs are in progress with Westinghouse, IBM, Gearhart, 3M, Arco (Atlantic Richfield), the American Iron and Steel Institute, Valmont, and Schlumberger in various technical areas including heatpipe design, lasers, electronics, materials, explosives, and computer-based modeling.
- The Laboratory has participated in two Laboratory-Industry forums and aimed at efficient matchmaking between Federal laboratories and individual companies. Several followup visits have been made and, as a result, one potential collaboration is being actively pursued.
- Several companies have visited the Laboratory for in-depth discussions of potential cooperation areas. These have included recently Phillips Petroleum, Westinghouse, Hoffman-La Roche, Honeywell, and Allied Corp.

## *UNIVERSITIES*

In several areas, cooperation with universities is intended to provide important linkages with US industry.

- The Laboratory is a member of the Center for Explosives Technology Research, along with New Mexico Tech, Sandia Laboratories, and the University of New Mexico. This cooperation directly benefits DOE programs at Los Alamos and has attracted industry involvement.
- The Laboratory has agreed to joint research with the New Mexico State University Plant Genetic Engineering Laboratory, one of the Rio Grande Research Corridor’s Centers of Excellence. The Laboratory and NMSU have organized a conference to kick off this collaboration and to attract industrial collaborators.

## *PATENT LICENSING*

During FY 1984, DOE has waived to the University of California title to several patents conceived at the Laboratory. Prior to this time, the inability of companies to gain exclusive patent licenses has been a major barrier to technology transfer on a small but important number of cases. The University has

- issued two patent licenses on optical keratoplasty, a method of correcting improper curvature of the eye's cornea, to a small new company,
- issued a letter of intent to license two inventions related to the use of light scattering to identify biological samples to a new company formed specifically to commercialize this technology, and
- begun preliminary discussions on the licensing of two other inventions.

## *COMMUNITY OUTREACH PROGRAMS*

The goal of the Laboratory's Outreach program is to create a "good neighbor policy" between the communities of northern New Mexico and the Laboratory. Implementation of this goal involves maintaining existing relationships, as well as establishing new relationships with community leaders and groups such as city and county elected officials, Native American tribal leaders, local educators, school boards, and chambers of commerce.

The main thrust of the Outreach program and the community contact has been the identification of community or group needs, particularly in the areas of education, technical assistance, and assisting in promoting northern New Mexico economic development.

The following can be highlighted as major accomplishments:

- The Laboratory's Christmas Drive exceeded the previous year's drive. The Laboratory assisted burn family victims throughout the year as a result of excess contributions.
- The New Mexico All Indian Pueblo Council governors and staff held their council meeting at the Laboratory in April.
- A two-day Laboratory workshop on careers in high technology was co-sponsored with the Los Alamos School District for the high school counselors of New Mexico.
- A high technology brochure was prepared, primarily for schools, depicting high technology companies of New Mexico, potential jobs, and the type of education required.
- The Educational Outreach effort introduced a new program for secondary mathematics/science teachers of New Mexico (Los Alamos Summer Science Teachers Institute—LASSTI). This year the four-week program targeted 17 high school chemistry teachers and was taught by MST Division and CHM Division.
- The Bradbury Science Museum piloted a Monday Morning Museum program, targeted for area elementary schools. The program offered 4th-6th graders the opportunity for an in-depth look at the Laboratory's history, research, and development. Invited Laboratory speakers talked about their work at Los Alamos, especially research relating to the museum exhibits.

In addition to reaching out to our neighboring communities, hundreds of students visit the Laboratory's Bradbury Science Museum for special films and programs, coming from as far away as the Taos Indian Day School and the Santa Fe School for the Deaf.

- The Careers in Science Program targets grades 7-10 and encourages early recognition of career goals by exposing young people to a variety of role models. Small panels of Laboratory employees—such as scientists, engineers, technicians, and people in administrative support roles—discuss their careers and how they became involved in their respective occupations. This is done through classroom presentations at the school. This year 35 schools were visited. A total of 145 presentations by Laboratory staff were given to approximately 6,125 students.

- This year's Science Youth Days program marked the 27th year of Laboratory participation. The Science Youth Day program is in conjunction with the Edison Science and Engineering Youth Day program established 29 years ago. The program attracted over 1000 students from 41 school districts in New Mexico, Texas, Colorado, and Arizona. Sixty-eight different programs were offered by 23 divisions. Approximately 55 Laboratory employees contributed a significant amount of time, with over 200 more contributing as the program developed.

In some cases teenagers spent much time raising money to fund the trip so they could take advantage of this program.

- The Los Alamos Science Student Program (LASSP) offered courses to high school juniors and seniors from Los Alamos, Santa Fe, Pojoaque, Española, and Jemez Valley High Schools after their regular school day. This program was developed to augment the regular school curriculum by offering classes using technology, equipment, and teachers that would be unavailable in local schools. Students are taught to use sophisticated word processors, machining equipment, electron microscopes, and various computers. Volunteers from the Laboratory's staff donate their evenings two days a week to serve as scientist-instructors to teach students how to use state-of-the-art equipment and introduce them to new scientific and technical areas. Sixteen courses were offered during the 1983-1984 school year to 128 students. Because classes are taught by volunteers, the courses offered vary from term to term. Students obtain school credits for their work. The school systems are supporting this program by funding buses that transport the students from their schools to Los Alamos and home again.

During the summer, a more intensive program for high school students is offered as a six-week session. The program targets northern New Mexico high school students who have completed their junior year. The main objective of this program is to allow students to design and develop a science project. Mornings are spent with skilled instructors who assist them in researching and designing their project. In the afternoon for two hours, four times a week, they spend time working on their projects with a Laboratory volunteer mentor at a Laboratory site. This year we had 21 students enrolled in the summer program.

- The programs for educational Outreach have been operating four years. Students are being tracked as they progress beyond these sessions, and we are already witnessing growth in the number of mathematics and science courses being offered in the schools. In addition, we have received excellent evaluations from participants, school teachers, and administrators and have a steadily increasing demand from school systems in the area for participation in all our programs. As the Assistant Principal of Santa Fe High School told his students: "Your participation in this program offers you a unique opportunity open to few students in the entire country. You should feel proud and fortunate to be part of this program."

### *RETIRED TECHNICAL VOLUNTEER SERVICE (RTVS)*

During the past year the Los Alamos National Laboratory has begun a technical volunteer program using retired employees. The program offers a way for retired scientists and engineers to volunteer their services and personal time in assisting northern New Mexico communities with increasingly complex technical problems often encountered.

This program is an outgrowth of a national pilot program to initiate such a technical volunteer service. Los Alamos National Laboratory was chosen to participate by the Federal Laboratory Consortium and the National Technical Volunteer Service Project Coordinator. The National Project Coordinator was funded by a grant from the Administration on Aging of the Department of Health and Human Services to provide training and consultation to the pilot laboratories.

Our achievements during the past year include:

- Establishment of a SKILLSBANK listing of available talents.
- Publication of a bimonthly newsletter mailed to all Laboratory retirees residing in New Mexico plus special interest groups. The newsletter contains items of general interest as well as topics regarding volunteerism.
- Assistance to city and county governments. Examples include advice given to a community about waste treatment plant problems and help given to another community in designing an electrical system for a museum.
- Assistance to nonprofit organizations. Examples are advice to a hospital on ways to protect monitoring equipment in the intensive care unit and computer assistance to another group.
- Assistance to the Eight Northern Indian Pueblo's Council through their administrative staff, by placement of volunteers and referrals of information.
- Volunteering through educational outreach programs, such as pairing up retirees and employees with promising young science students.

Contacts have been made with some of the New Mexico state agencies. The beginning of volunteer placements with these groups is underway. Examples of help requested include evaluation of technical proposals for one state agency, investigation of transportation requests by Senior Citizen Centers of northern New Mexico, a long-term planning study to be made on impact to the state of increased numbers of retired persons moving into the area, and advice and possible work assignments at remote locations (such as fish hatcheries) that may be located in the seven northern New Mexico counties.

Information about other volunteer assignments within the United States is of interest to some retirees. Currently we are investigating the possibility of cooperation with the National Park Service. Some volunteers have a great interest in international volunteering. The Retired Technical Volunteer Service (RTVS) office serves as a clearinghouse of information and possible contacts.

Other federal laboratories are embarking on new programs similar to ours. Contacts with those volunteer offices, both on a one-on-one basis and through national group meetings, are ongoing.

Expansion being explored for the Los Alamos National Laboratory volunteer program includes movement in two directions: the recruitment of Laboratory employees to perform volunteer tasks on their own time and additional referrals given to small business firms that qualify under certain specific guidelines.

## *BRADBURY SCIENCE MUSEUM*

The Bradbury Science Museum provides information about Laboratory history and research projects to official visitors, students, and the general public. This is accomplished through educational exhibits, films, and special orientation programs given by the staff. It is estimated that approximately 85,000 visitors will have visited the Bradbury Science Museum this year (1984). Additionally, exhibits are provided off-site for technical and public conferences and exhibitions.

A project to renovate Museum exhibits began in 1981 and is now complete. The renovation project has broadened the scope of Museum exhibits to include state-of-the-art technologies and a more comprehensive history of the Laboratory and the events leading to its development.

## *LABORATORY COLLABORATIVE RESEARCH CENTERS*

Los Alamos has made a major commitment to a broad range of scientific collaboration with universities and industry and backs that commitment by providing access to many of its facilities available on a noninterference basis. Descriptions of 30 such facilities, with arrangements and contacts, are available to potential users.

The major dedicated users' facility in FY 1983 was LAMPF. Most experiments are collaborative efforts between Laboratory staff and experimentalists from other institutions, primarily universities. For this reason, we cannot accurately apportion the relative use by outside participants, although the numbers of experimental personnel given below provide a crude measure.

	<u>FY 1978</u>	<u>FY 1979</u>	<u>FY 1980</u>	<u>FY 1981</u>	<u>FY 1982</u>	<u>FY 1983</u>
<u>Experimenter Personnel</u>						
Los Alamos	100	131	123	128	102	167
Other (mostly university)	289	242	319	314	346	433
Operating Budget (\$ in millions)	18.8	21.0	22.8	23.2	26.3	29.8

A major new user program in condensed matter research using pulsed-neutron-scattering techniques was begun in FY 1983. With completion of the PSR, this program will grow to full strength in FY 1986, when more than 100 visitors per year from national laboratories, industry, and universities are expected.

In addition, in the life sciences, we operate a number of centers jointly funded with the National Institutes of Health (NIH). These include the National Flow Cytometry Resource, the National Genetic Sequence Data Bank (GENBANK), and the National Stable Isotope Resource.

## *UNIVERSITY/LABORATORY PROGRAMS*

We are committed and dedicated to the belief that appropriate interactions and collaboration with the university community, when such interactions bring benefits to both the Laboratory and the university, are important to the vitality and productivity of our research programs.

The Laboratory maintains relationships of varying kinds with about 33 members of its User's Group.

As an indication of the Laboratory's commitment to education and research collaborations with the University community, we maintain formal consulting and collaborator agreements with 977 faculty or staff from 288 colleges and universities throughout the United States and around the world. In addition, during 1984, 302 undergraduate students and 183 graduate research assistants

were employed by the Laboratory, primarily in summer positions. Seventy-five postdoctoral appointees are currently conducting postdoctoral research, an increase of about 20% from 1983.

We are also a long-time participant in the Laboratory Cooperation Program, particularly through our relationship with Associated Western Universities (AWU), Inc. During the past year, 30 students and faculty of AWU member universities were involved in thesis research, graduate assistantships, and faculty appointments.

During recent years, as the Laboratory's research responsibilities have diversified, the amount and kinds of interactions and collaborative efforts between the staff at Los Alamos and the faculty of our parent institution, the University of California, have increased dramatically. This increasingly significant phenomenon has been triggered in large measure by the establishment at Los Alamos of a branch of the Institute of Geophysics and Planetary Physics (IGPP), whose headquarters reside on the UCLA campus.

Since its establishment in 1980, the Los Alamos branch of IGPP has sponsored numerous research projects and summer field studies in the earth and space sciences. Twenty-six research projects are presently underway by Los Alamos scientists and University of California faculty and graduate students. More than 100 such collaborative efforts have been sponsored by the IGPP since its inception.

Although the IGPP has undoubtedly been the catalyst for increased collaborations between the Laboratory and the University of California, these interactions have not been limited to the fields of earth and space sciences. Most of the research programs at Los Alamos are represented in collaborative research, and all nine campuses of the University of California have participated with nearly all Laboratory divisions in work ranging from controlled thermonuclear research to reactor safety to cancer therapy. Nearly 10% of the Laboratory's 977 consultants and collaborators are from University of California campuses. The other multidisciplinary centers of the Laboratory, the Center for Nonlinear Studies and the Center for Materials Science, are also highly involved with UC collaborations, and discussions are underway about the possibility of establishing a Center for Nonlinear Studies at the University of California as an organized research unit of the University.

Close ties with New Mexico's academic institutions are an important component of our university interactions. UNM has for 28 years operated the Center for Graduate Studies under contract with the Laboratory, which provides residence-credit graduate programs leading to the M.S. and Ph.D. degrees. UNM and Los Alamos also jointly operate the newly established Noninvasive Diagnostic Center using NMR imaging as a tool for diagnosis of cancer.

In fact, there are two dozen research areas in which Laboratory researchers and UNM Medical School faculty have established collaborative endeavors.

We also maintain strong ties with New Mexico State University and the New Mexico Institute of Mining and Technology (NMIMT), particularly in our support of recently established "Centers of Excellence" at those institutions: Computing and Plant Genetics at New Mexico State and Explosives Technologies at NMIMT. As an example, Los Alamos has joined with SNLA, NMIMT, and UNM to form a Consortium for Explosives Technology to further technology transfer to industry and to provide closer ties for collaborative research in explosives science.

At the same time, the Center for Explosives Technology Research (CETR) has been established at NMIMT as a state-supported Center of Excellence. The CETR will be closely allied with the Consortium with parallel goals. Among these are the education of people in explosive science, research in explosives development, explosive device design and testing, and the shock modification of materials. The capabilities, interests, and needs of the four institutions are complementary. Among us we have a complete explosives technology.

Los Alamos is helping to set up both centers. Two of our scientists are members of the CETR Technical Advisory Committee and a third is the Los Alamos member of the Board of Directors of the Consortium. We are planning collaborative programs in industrial application of explosives and in explosives research. We expect interchange of staff and collaboration in joint research using the appropriate facilities at the different institutions in programs of mutual interest.

By 1990, we expect the CETR to be operating independently and working with the Consortium to provide trained people in energetic material technology, research facilities with new capabilities useful to Los Alamos, and an established technology transfer process.

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## **VIII. RESOURCE PROJECTIONS**

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## **LABORATORY FUNDING AND PERSONNEL SUMMARY**

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OVERALL LABORATORY SUMMARY

FUNDING SUMMARY

(\$ in millions - BA)	FY 1984 Actual	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990
DOE Effort	530.8	553.9	661.7	632.1	627.9	629.5	629.4
Work for Others	<u>86.0</u>	<u>87.5</u>	<u>92.5</u>	<u>98.5</u>	<u>100.4</u>	<u>99.7</u>	<u>99.7</u>
Total Operating	616.8	641.4	754.2	730.6	728.3	729.2	729.1
Capital Equipment	33.5	33.3	67.0	59.5	59.4	59.7	60.9
Program Construction	31.2	49.2	74.3	151.7	71.2	50.0	20.0
General Plant Projects	<u>7.3</u>	<u>8.2</u>	<u>30.4</u>	<u>30.4</u>	<u>30.4</u>	<u>30.4</u>	<u>30.4</u>
Total Laboratory Funding	688.8	732.1	925.9	972.2	889.3	869.3	840.4
Proposed Construction	<u>0</u>	<u>4.0</u>	<u>38.0</u>	<u>71.6</u>	<u>177.0</u>	<u>209.1</u>	<u>191.4</u>
Total	688.8	736.1	963.9	1043.8	1066.3	1078.4	1031.8

PERSONNEL SUMMARY

(Personnel in FTE)	FY 1984 Actual	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990
DOE Effort	4229	4266	4349	4339	4325	4330	4330
Work For Others	647	604	591	601	615	610	610
Total Operating	4876	4870	4940	4940	4940	4940	4940
Construction	91	100	100	100	100	100	100
Total Direct Charge	4967	4970	5040	5040	5040	5040	5040
Direct Recharge (Support)	832	880	888	888	888	888	888
Total Direct	5799	5850	5928	5928	5928	5928	5928
Indirect	1658	1650	1672	1672	1672	1672	1672
Total Laboratory Personnel	7457	7500	7600	7600	7600	7600	7600

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**FUNDING BY SECRETARIAL OFFICER**

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FUNDING BY ASSISTANT SECRETARIAL LEVEL OFFICE

(\$ IN MILLIONS - BA)	(A)		(B)		FY 1988	FY 1989	FY 1990
	FY 1984	FY 1985	FY 1986	FY 1987			
<b>DEFENSE PROGRAMS</b>							
Total Operating	374.8	407.0	466.7	436.8	436.9	439.5	439.0
Capital Equipment	26.8	23.8	52.3	46.0	46.4	46.7	47.8
Construction	30.7	48.2	72.2	143.2	71.2	50.0	20.0
Subtotal-DP	432.3	479.0	591.2	626.0	554.5	536.2	506.8
<b>ENERGY RESEARCH</b>							
Total Operating	85.5	86.8	116.2	118.4	116.1	115.8	115.9
Capital Equipment	5.9	5.6	11.0	10.3	10.7	10.7	10.4
Construction	0.5	1.0	0.3	2.7	0.0	0.0	0.0
Subtotal-ER	91.9	93.4	127.5	131.4	126.8	126.5	126.3
<b>NUCLEAR ENERGY</b>							
Total Operating	16.9	16.0	17.5	19.8	19.1	18.7	18.8
Capital Equipment	0.2	0.2	1.4	1.4	1.4	1.4	1.4
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal-NE	17.1	16.2	18.9	21.2	20.5	20.1	20.2
<b>CONSERVATION/RENEW ENERGY</b>							
Total Operating	11.7	10.5	13.5	10.4	8.6	8.6	8.5
Capital Equipment	0.1	0.2	0.0	0.0	0.0	0.0	0.4
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal-CE	11.8	10.7	13.5	10.4	8.6	8.6	8.9
<b>FOSSIL ENERGY</b>							
Total Operating	3.5	2.4	5.5	5.4	5.4	5.2	5.2
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal-FE	3.5	2.4	5.5	5.4	5.4	5.2	5.2
<b>POLICY/SAFETY/ENVIRONMENT</b>							
Total Operating	1.7	2.4	3.5	3.6	3.8	4.0	3.9
Capital Equipment	0.1	0.1	0.2	0.2	0.2	0.2	0.2
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal-PSE	1.8	2.5	3.7	3.8	4.0	4.2	4.1
<b>INT'L AFFAIRS/ENERGY EMER</b>							
Total Operating	0.0	0.1	0.1	0.1	0.1	0.1	0.1
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal-IA	0.0	0.1	0.1	0.1	0.1	0.1	0.1

(A) Escalation Factor 7.9 percent for FY85.

(B) Escalation Factor 7.8 percent for FY86; constant FY86 dollars after FY86.

## FUNDING BY ASSISTANT SECRETARIAL LEVEL OFFICE

(\$ IN MILLIONS - BA)	(A)		(B)		FY 1988	FY 1989	FY 1990
	FY 1984	FY 1985	FY 1986	FY 1987			
<b>MANAGEMENT &amp; ADMINISTRATION</b>							
Total Operating	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	1.8	5.8	0.0	0.0	0.0
Subtotal-MA	0.2	0.0	1.8	5.8	0.0	0.0	0.0
<b>NUC WASTE POLICY PROJ OFFICE</b>							
Total Operating	9.3	0.0	12.8	11.2	6.6	6.3	6.7
Capital Equipment	0.2	1.3	1.8	1.4	0.5	0.5	0.5
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal-MA	9.5	1.3	14.6	12.6	7.1	6.8	7.2
<b>WFO - DOE</b>							
Total Operating	27.4	28.7	26.1	26.5	31.3	31.3	31.3
Capital Equipment	0.0	1.6	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	27.4	30.3	26.1	26.5	31.3	31.3	31.3
<b>TOTAL DOE</b>							
Total Operating	530.8	553.9	661.7	632.1	627.9	629.5	629.4
Capital Equipment	33.3	32.8	66.7	59.3	59.2	59.5	60.7
Construction	31.2	49.2	74.3	151.7	71.2	50.0	20.0
Total	595.3	635.9	802.7	843.1	758.3	739.0	710.1
<b>WFO - NON DOE - DOD</b>							
Total Operating	49.4	49.0	55.0	61.0	61.0	61.0	61.0
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	49.4	49.0	55.0	61.0	61.0	61.0	61.0
<b>WFO - NON DOE - NRC</b>							
Total Operating	15.1	12.6	13.0	13.0	13.0	13.0	13.0
Capital Equipment	0.2	0.5	0.3	0.2	0.2	0.2	0.2
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	15.3	13.1	13.3	13.2	13.2	13.2	13.2
<b>WFO - NON DOE - OTHER</b>							
Total Operating	21.5	25.9	24.5	24.5	26.4	25.7	25.7
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	21.5	25.9	24.5	24.5	26.4	25.7	25.7

(A) Escalation Factor 7.9 percent for FY85.

(B) Escalation Factor 7.8 percent for FY86; constant FY86 dollars after FY86.

FUNDING BY ASSISTANT SECRETARIAL LEVEL OFFICE

(\$ IN MILLIONS - BA)	(A)		(B)		FY 1987	FY 1988	FY 1989	FY 1990
	FY 1984	FY 1985	FY 1986	FY 1986				
WORK FOR OTHERS - NOM DOE								
Total Operating	86.0	87.5	92.5	98.5	100.4	99.7	99.7	
Capital Equipment	0.2	0.5	0.3	0.2	0.2	0.2	0.2	
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Total	86.2	88.0	92.8	98.7	100.6	99.9	99.9	
WORK FOR OTHERS								
Total Operating	113.4	116.2	118.6	125.0	131.7	131.0	131.0	
Capital Equipment	0.2	2.1	0.3	0.2	0.2	0.2	0.2	
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Total-WFO	113.6	118.3	118.9	125.2	131.9	131.2	131.2	
General Plant Projects	7.3	8.2	30.4	30.4	30.4	30.4	30.4	
Total Laboratory Funding								
Total Operating	616.8	641.4	754.2	730.6	728.3	729.2	729.1	
Capital Equipment	33.5	33.3	67.0	59.5	59.4	59.7	60.9	
Construction	38.5	57.4	104.7	182.1	101.6	80.4	50.4	
Total	688.8	732.1	925.9	972.2	889.3	869.3	840.4	
Proposed Construction		4.0	38.0	71.6	177.0	209.1	191.4	
Total Including Proposed Const								
Total Operating	616.8	641.4	754.2	730.6	728.3	729.2	729.1	
Capital Equipment	33.5	33.3	67.0	59.5	59.4	59.7	60.9	
Construction	38.5	61.4	142.7	253.7	278.6	289.5	241.8	
Total	688.8	736.1	963.9	1043.8	1066.3	1078.4	1031.8	

(A) Escalation Factor 7.9 percent for FY85.

(B) Escalation Factor 7.8 percent for FY86; constant FY86 dollars after FY86.

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**DIRECT PERSONNEL BY SECRETARIAL OFFICER**

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PERSONNEL BY ASSISTANT SECRETARIAL LEVEL OFFICE

<u>(PERSONNEL IN FTE)</u>	<u>FY 1984</u>	<u>FY 1985</u>	<u>FY 1986</u>	<u>FY 1987</u>	<u>FY 1988</u>	<u>FY 1989</u>	<u>FY 1990</u>
DEFENSE PROGRAMS Direct Personnel	2811	2883	2900	2823	2802	2812	2812
ENERGY RESEARCH Direct Personnel	790	792	884	943	943	943	943
NUCLEAR ENERGY Direct Personnel	166	109	118	130	130	130	130
CONSERVATION/RENEWABLE ENERGY Direct Personnel	100	86	66	63	47	47	47
FOSSIL ENERGY Direct Personnel	32	22	38	42	40	40	40
POLICY/SAFETY/ENVIRONMENT Direct Personnel	18	21	27	29	31	32	32
INTERNATIONAL AFFAIRS/ENERGY EMERGENCY Direct Personnel	0	1	1	1	1	1	1
NUCLEAR WASTE POLICY PROJECT OFFICE Direct Personnel	80	74	80	70	49	43	43
WFO DOE Direct Personnel	232	278	235	238	282	282	282
Total DOE Programs Direct Personnel	4229	4266	4349	4339	4325	4330	4330
WFO-Non DOE DoD Programs Direct Personnel	361	314	325	336	336	336	336
WFO-Non DOE NRC Programs Direct Personnel	114	92	92	92	92	92	92
WFO-Non DOE Other Direct Personnel	172	198	174	173	187	182	182
Total WFO-Non DOE Direct Personnel	647	604	591	600	614	609	609
Direct Recharge	832	880	888	888	888	888	888
Construction	91	100	100	100	100	100	100
Total Laboratory - Direct	5799	5850	5928	5928	5928	5928	5928
Total Laboratory - Indirect	1658	1650	1672	1672	1672	1672	1672
Total Laboratory Personnel	7457	7500	7600	7600	7600	7600	7600

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## **RESOURCES BY MAJOR PROGRAM**

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RESOURCES BY SUB PROGRAM  
 ASSISTANT SECRETARY FOR DEFENSE PROGRAMS  
 (\$ IN MILLIONS - PERSONNEL IN FTE)

	FY84 Actual		A		B		FY 1987		FY 1988		FY 1989		FY 1990	
	BA	Costs	FY 1985 BA	BO	FY 1986 BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
AR05 DEFENSE WASTE														
Total Operating	5.9	5.9	6.5	6.0	8.7	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Capital Equipment	0.8	0.8	0.6	0.6	1.6	1.6	0.0	0.0	0.0	0.0	0.0	0.0	1.6	1.6
Construction	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
Subtotal	6.7	6.7	7.1	6.6	10.3	9.6	8.0	8.0	8.0	8.0	8.0	8.0	9.6	9.6
Direct Personnel		69		84		84		84		84		84		84
AR-DEFENSE WASTE MANAGEMENT														
Total Operating	5.9	5.9	6.5	6.0	8.7	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Capital Equipment	0.8	0.8	0.6	0.6	1.6	1.6	0.0	0.0	0.0	0.0	0.0	0.0	1.6	1.6
Construction	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
Total AR	6.7	6.7	7.1	6.6	10.3	9.6	8.0	8.0	8.0	8.0	8.0	8.0	9.6	9.6
Direct Personnel		69		84		84		84		84		84		84
GB01 R&D TESTING														
Total Operating	242.5	242.9	273.5	263.5	308.6	297.3	297.3	297.3	297.3	297.3	297.3	297.3	297.3	297.3
Capital Equipment	14.3	14.3	17.6	17.6	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0
Construction	15.6	20.1	23.0	25.6	36.1	30.9	105.7	91.9	56.6	71.7	50.0	42.8	20.0	21.0
Subtotal	272.4	277.3	314.1	306.7	376.7	360.2	435.0	421.2	385.9	401.0	379.3	372.1	349.3	350.3
Direct Personnel		1695		1750		1797		1796		1794		1793		1793
GB02 INERT CONF FUS														
Total Operating	43.6	45.0	30.5	30.5	52.1	46.7	46.7	46.7	46.7	46.7	46.7	46.7	46.7	46.7
Capital Equipment	2.8	2.8	2.0	2.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Construction	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
Subtotal	46.4	47.8	32.5	32.5	57.1	51.7	51.7	51.7	51.7	51.7	51.7	51.7	51.7	51.7
Direct Personnel		299		234		243		243		243		243		243
GB03 WEAP PROD/SURV														
Total Operating	17.2	15.7	16.6	16.6	19.1	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5
Capital Equipment	4.5	4.5	0.1	0.1	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6
Construction	15.1	15.1	16.6	16.6	20.2	20.2	24.8	24.8	14.6	14.6	0.0	0.0	0.0	0.0
Subtotal	36.8	35.3	33.3	33.3	43.9	43.3	47.9	47.9	37.7	37.7	23.1	23.1	23.1	23.1
Direct Personnel		155		142		151		151		151		151		151
GB-WEAPONS ACTIVITIES														
Total Operating	303.3	303.6	320.6	310.6	379.8	362.5	362.5	362.5	362.5	362.5	362.5	362.5	362.5	362.5
Capital Equipment	21.6	21.6	19.7	19.7	41.6	41.6	41.6	41.6	41.6	41.6	41.6	41.6	41.6	41.6
Construction	30.7	35.2	39.6	42.2	56.3	51.1	130.5	116.7	71.2	86.3	50.0	42.8	20.0	21.0
Total GB	355.6	360.4	379.9	372.5	477.7	455.2	534.6	520.8	475.3	490.4	454.1	446.9	424.1	425.1
Direct Personnel		2149		2126		2191		2190		2188		2187		2187

A--ESCALATION FACTOR 7.9% FOR 85.  
 B--ESCALATION FACTOR 7.8% FOR FY 86; CONSTANT FY 86 DOLLARS AFTER FY 86.

RESOURCES BY SUB PROGRAM  
 ASSISTANT SECRETARY FOR DEFENSE PROGRAMS  
 (\$ IN MILLIONS - PERSONNEL IN FTE)

	FY84 BA	Actual Costs	A		B		FY 1987		FY 1988		FY 1989		FY 1990	
			FY 1985 BA	BO	FY 1986 BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
GC01 VER & CNTR TECH														
Total Operating	14.9	17.3	20.3	19.8	21.8	21.3	19.4	19.9	20.2	20.1	21.7	21.3	21.3	21.3
Capital Equipment	0.4	0.4	0.5	0.5	1.0	1.0	1.1	1.1	1.3	1.3	1.4	1.4	0.9	0.9
Construction	0.0	0.0	1.0	0.6	5.5	3.3	1.0	3.5	0.0	0.1	0.0	0.0	0.0	0.0
Subtotal	15.3	17.7	21.8	20.9	28.3	25.6	21.5	24.5	21.5	21.5	23.1	22.7	22.2	22.2
Direct Personnel		143		145		145		135		137		145		145
GC-VERIFICATION & CONTR TECH														
Total Operating	14.9	17.3	20.3	19.8	21.8	21.3	19.4	19.9	20.2	20.1	21.7	21.3	21.3	21.3
Capital Equipment	0.4	0.4	0.5	0.5	1.0	1.0	1.1	1.1	1.3	1.3	1.4	1.4	0.9	0.9
Construction	0.0	0.0	1.0	0.6	5.5	3.3	1.0	1.0	0.0	0.1	0.0	0.0	0.0	0.0
Total GC	15.3	17.7	21.8	20.9	28.3	25.6	21.5	24.5	21.5	21.5	23.1	22.7	22.2	22.2
Direct Personnel		143		145		145		135		137		145		145
GD02 NUC MTL SEC&SFG														
Total Operating	10.8	10.8	13.2	13.2	14.5	14.2	14.7	14.6	16.6	16.1	16.1	16.1	16.1	16.1
Capital Equipment	1.2	1.2	1.3	1.3	1.7	1.7	2.2	2.2	2.4	2.4	2.6	2.6	2.6	2.6
Construction	0.0	0.0	7.6	7.6	10.4	8.7	11.7	5.1	0.0	7.1	0.0	1.2	0.0	0.0
Subtotal	12.0	12.0	22.1	22.1	26.6	24.6	28.6	21.9	19.0	25.6	18.7	19.9	18.7	18.7
Direct Personnel		95		117		117		120		132		132		132
GD-NUC MTL S SAFEGUARDS & SEC														
Total Operating	10.8	10.8	13.2	13.2	14.5	14.2	14.7	14.6	16.6	16.1	16.1	16.1	16.1	16.1
Capital Equipment	1.2	1.2	1.3	1.3	1.7	1.7	2.2	2.2	2.4	2.4	2.6	2.6	2.6	2.6
Construction	0.0	0.0	7.6	7.6	10.4	8.7	11.7	11.7	0.0	7.1	0.0	1.2	0.0	0.0
Total GD	12.0	12.0	22.1	22.1	26.6	24.6	28.6	21.9	19.0	25.6	18.7	19.9	18.7	18.7
Direct Personnel		95		117		117		120		132		132		132
GE02 NUC MATL PROC														
Total Operating	37.0	35.8	43.9	40.3	35.6	36.8	23.1	26.5	21.6	22.8	23.1	23.0	23.0	23.0
Capital Equipment	2.8	2.8	1.7	1.7	5.8	5.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Construction	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
Subtotal	39.8	38.6	45.6	42.0	41.4	42.6	23.9	27.3	22.4	23.6	23.9	23.8	23.8	23.8
Direct Personnel		330		379		324		233		200		203		203
GE03 SUP SERVICES														
Total Operating	2.9	2.9	2.5	2.1	6.2	5.2	9.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
Capital Equipment	0.0	0.0	0.0	0.0	0.6	0.6	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Construction	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
Subtotal	2.9	2.9	2.5	2.1	6.8	5.8	9.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4
Direct Personnel		25		32		39		61		61		61		61

A--ESCALATION FACTOR 7.9% FOR 85.

B--ESCALATION FACTOR 7.8% FOR FY 86; CONSTANT FY 86 DOLLARS AFTER FY 86.

RESOURCES BY SUB PROGRAM  
 ASSISTANT SECRETARY FOR DEFENSE PROGRAMS  
 (\$ IN MILLIONS - PERSONNEL IN FTE)

	FY84 Actual		A		B		FY 1987		FY 1988		FY 1989		FY 1990	
	BA	Costs	FY 1985 BA	BO	FY 1986 BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
GE-MATERIALS PRODUCTION														
Total Operating	39.9	38.7	46.4	42.4	41.9	42.0	32.1	34.6	29.7	30.9	31.2	31.1	31.1	31.1
Capital Equipment	2.8	2.8	1.7	1.7	6.4	6.4	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Construction	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
Total GE	42.7	41.5	48.1	44.1	48.3	48.4	33.2	35.7	30.8	32.0	32.3	32.2	32.2	32.2
Direct Personnel		355		411		363		294		261		264		264
DEFENSE PROGRAMS														
Total Operating	374.8	376.3	407.0	392.0	466.7	448.0	436.8	439.6	436.9	437.6	439.5	439.0	439.0	439.0
Capital Equipment	26.8	26.8	23.8	23.8	52.3	52.3	46.0	46.0	46.4	46.4	46.7	46.7	47.8	47.8
Construction	30.7	35.2	48.2	50.4	72.2	63.1	143.2	143.2	71.2	93.5	50.0	44.0	20.0	20.0
Total DP	432.3	438.3	479.0	466.2	591.2	563.4	626.0	610.9	554.5	577.5	536.2	529.7	506.8	507.8
Direct Personnel		2811		2883		2900		2823		2802		2812		2812

A--ESCALATION FACTOR 7.9% FOR 85.

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RESOURCES BY SUB PROGRAM  
 ASSISTANT SECRETARY FOR ENERGY RESEARCH  
 (\$ IN MILLIONS - PERSONNEL IN FTE)

	FY84 Actual		A		B		FY 1987		FY 1988		FY 1989		FY 1990	
	BA	Costs	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
AT05 APPL PLASMA PHY														
Total Operating	16.3	15.9	15.1	14.8	21.3	19.7	20.0	19.9	19.6	19.7	19.2	19.3	19.3	19.3
Capital Equipment	0.7	0.7	0.9	0.9	1.8	1.8	1.1	1.1	1.5	1.5	1.4	1.4	1.1	1.1
Construction	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
Subtotal	17.0	16.6	16.0	15.7	23.1	21.5	21.1	21.0	21.1	21.2	20.6	20.7	20.4	20.4
Direct Personnel		153		160		169		171		169		166		166
AT15 DEVELOP & TECH														
Total Operating	3.6	3.5	3.8	3.8	6.1	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
Capital Equipment	0.3	0.3	0.1	0.1	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Construction	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
Subtotal	3.9	3.8	3.9	3.9	6.4	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8
Direct Personnel		35		38		44		44		44		44		44
AT-MAGNETIC FUSION														
Total Operating	19.9	19.4	18.9	18.6	27.4	25.2	25.5	25.4	25.1	25.2	24.7	24.8	24.8	24.8
Capital Equipment	1.0	1.0	1.0	1.0	2.1	2.1	1.4	1.4	1.8	1.8	1.7	1.7	1.4	1.4
Construction	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
Total AT	20.9	20.4	19.9	19.6	29.5	27.3	26.9	26.8	26.9	27.0	26.4	26.5	26.2	26.2
Direct Personnel		188		198		213		215		213		210		210
HA02 BIO & ENVN RES														
Total Operating	11.4	10.7	10.4	10.4	13.1	12.4	13.7	13.4	13.8	13.7	14.0	13.9	13.9	13.9
Capital Equipment	0.6	0.6	0.5	0.5	1.4	1.4	1.4	1.4	1.4	1.4	1.5	1.5	1.5	1.5
Construction	0.0	0.0	0.0	0.0	0.3	0.2	2.7	2.3	0.0	0.5	0.0	0.0	0.0	0.0
Subtotal	12.0	11.3	10.9	10.9	14.8	14.0	17.8	17.1	15.2	15.6	15.5	15.4	15.4	15.4
Direct Personnel		113		106		122		132		134		137		137
HA-ENVIRONMENTAL R&D														
Total Operating	11.4	10.7	10.4	10.4	13.1	12.4	13.7	13.4	13.8	13.7	14.0	13.9	13.9	13.9
Capital Equipment	0.6	0.6	0.5	0.5	1.4	1.4	1.4	1.4	1.4	1.4	1.5	1.5	1.5	1.5
Construction	0.0	0.0	0.0	0.0	0.3	0.2	2.7	2.7	0.0	0.5	0.0	0.0	0.0	0.0
Total HA	12.0	11.3	10.9	10.9	14.8	14.0	17.8	17.1	15.2	15.6	15.5	15.4	15.4	15.4
Direct Personnel		113		106		122		132		134		137		137
HB01 GENL LIFE SCI														
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
Capital Equipment	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
Construction	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
Subtotal	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		2		0		0		0		0		0		0

A--ESCALATION FACTOR 7.9% FOR 85.

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RESOURCES BY SUB PROGRAM  
 ASSISTANT SECRETARY FOR ENERGY RESEARCH  
 (\$ IN MILLIONS - PERSONNEL IN FTE)

	FY84 Actual		A		B		FY 1987		FY 1988		FY 1989		FY 1990	
	BA	Costs	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
HB02 NUCLR MEDICINE														
Total Operating	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	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
Construction	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
Subtotal	0.0	0.7	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		8		0		0		0		0		0		0
HB-LFE SCI RES & NUC MED APP														
Total Operating	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	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
Construction	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
Total HB	0.0	0.9	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		10		0		0		0		0		0		0
KA01 PHYSICS RESRCH														
Total Operating	0.5	0.4	0.4	0.4	2.4	1.9	2.8	2.6	2.6	2.6	2.6	2.6	2.6	2.6
Capital Equipment	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Construction	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
Subtotal	0.5	0.4	0.4	0.4	2.5	2.0	2.9	2.7	2.7	2.7	2.7	2.7	2.7	2.7
Direct Personnel		3		4		17		24		24		24		24
KA03 PLASMA HEAT ACCEL														
Total Operating	0.2	0.2	0.0	0.0	1.5	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Capital Equipment	0.0	0.0	0.0	0.0	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Construction	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
Subtotal	0.2	0.2	0.0	0.0	1.7	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Direct Personnel		1		2		7		7		7		7		7
KA-HIGH ENERGY PHYSICS														
Total Operating	0.7	0.6	0.4	0.4	3.9	3.0	3.9	3.7	3.7	3.7	3.7	3.7	3.7	3.7
Capital Equipment	0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Construction	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
Total KA	0.7	0.6	0.4	0.4	4.2	3.3	4.2	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Direct Personnel		4		6		24		31		31		31		31
KB01 MED ENERGY PHY														
Total Operating	38.4	41.1	43.9	44.4	51.2	49.5	50.8	50.5	50.5	50.5	50.5	50.5	50.5	50.5
Capital Equipment	2.7	2.7	2.7	2.7	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Construction	0.5	0.5	1.0	0.2	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	41.6	44.3	47.6	47.3	55.2	54.3	54.8	54.5	54.5	54.5	54.5	54.5	54.5	54.5
Direct Personnel		366		371		385		392		392		392		392

A--ESCALATION FACTOR 7.9% FOR 85.  
 B--ESCALATION FACTOR 7.8% FOR FY 86; CONSTANT FY 86 DOLLARS AFTER FY 86.

RESOURCES BY SUB PROGRAM  
 ASSISTANT SECRETARY FOR ENERGY RESEARCH  
 (\$ IN MILLIONS - PERSONNEL IN FTE)

	FY84 BA	Actual Costs	A		B		FY 1987		FY 1988		FY 1989		FY 1990	
			FY 1985 BA	BO	FY 1986 BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
KB02 HEAVY ION PHYS														
Total Operating	0.2	0.1	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Capital Equipment	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Construction	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
Subtotal	0.3	0.2	0.2	0.2	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Direct Personnel		1		1		2		2		2		2		2
KB03 NUCLEAR THEORY														
Total Operating	1.0	1.0	1.0	1.1	1.5	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Capital Equipment	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Construction	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
Subtotal	1.0	1.0	1.0	1.1	1.6	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Direct Personnel		10		9		10		10		10		10		10
KB04 LOW ENERGY PHYS														
Total Operating	0.5	0.4	0.4	0.4	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Capital Equipment	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Construction	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
Subtotal	0.6	0.5	0.4	0.4	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Direct Personnel		4		3		4		4		4		4		4
KB-NUCLEAR PHYSICS														
Total Operating	40.1	42.6	45.5	46.1	53.8	51.9	53.2	52.9	52.9	52.9	52.9	52.9	52.9	52.9
Capital Equipment	2.9	2.9	2.7	2.7	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
Construction	0.5	0.5	1.0	0.2	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total KB	43.5	46.0	49.2	49.0	58.1	57.0	57.5	57.2	57.2	57.2	57.2	57.2	57.2	57.2
Direct Personnel		381		384		401		408		408		408		408
KC01 NUCLEAR SCI														
Total Operating	2.3	2.2	2.9	2.9	4.6	4.2	6.2	5.7	5.7	5.7	5.7	5.7	5.7	5.7
Capital Equipment	0.1	0.1	0.1	0.1	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Construction	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
Subtotal	2.4	2.3	3.0	3.0	5.2	4.8	6.8	6.3	6.3	6.3	6.3	6.3	6.3	6.3
Direct Personnel		18		21		27		37		37		37		37
KC02 MATERIAL SCI														
Total Operating	4.0	4.0	4.0	4.0	7.5	6.6	10.2	9.3	9.3	9.3	9.3	9.3	9.3	9.3
Capital Equipment	0.9	0.9	0.9	0.9	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Construction	0.0	1.8	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	4.9	6.7	4.9	5.1	9.3	8.4	12.0	11.1	11.1	11.1	11.1	11.1	11.1	11.1
Direct Personnel		35		40		54		77		77		77		77

Los Alamos

A--ESCALATION FACTOR 7.9% FOR 85.

B--ESCALATION FACTOR 7.8% FOR FY 86; CONSTANT FY 86 DOLLARS AFTER FY 86.

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 ASSISTANT SECRETARY FOR ENERGY RESEARCH  
 (\$ IN MILLIONS - PERSONNEL IN FTE)

	FY84 BA	Actual Costs	A FY 1985		B FY 1986		FY 1987		FY 1988		FY 1989		FY 1990	
			BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
KC03 CHEMICAL SCI														
Total Operating	0.8	0.7	0.5	0.5	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Capital Equipment	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
Construction	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
Subtotal	0.9	0.8	0.6	0.6	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Direct Personnel		5		4		7		7		7		7		7
KC04 ENG MATH & GEO														
Total Operating	3.7	3.6	3.0	3.0	3.5	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
Capital Equipment	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Construction	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
Subtotal	3.9	3.8	3.2	3.2	3.8	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7
Direct Personnel		27		23		28		28		28		28		28
KC05 ADV ENERGY PROJ														
Total Operating	2.6	1.4	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Capital Equipment	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
Construction	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
Subtotal	2.7	1.5	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Direct Personnel		9		10		8		8		8		8		8
KC-BASIC ENERGY SCIENCES														
Total Operating	13.4	11.9	11.6	11.6	17.9	16.3	21.9	20.5	20.5	20.5	20.5	20.5	20.5	20.5
Capital Equipment	1.4	1.4	1.4	1.4	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
Construction	0.0	1.8	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total KC	14.8	15.1	13.0	13.2	20.8	19.2	24.8	23.4	23.4	23.4	23.4	23.4	23.4	23.4
Direct Personnel		94		98		124		157		157		157		157
KE01 UNIV RSRCH SUPP														
Total Operating	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Capital Equipment	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
Construction	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
Subtotal	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Direct Personnel		0		0		0		0		0		0		0
KE-UNIVERSITY RESEARCH SUP														
Total Operating	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Capital Equipment	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
Construction	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
Total KE	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Direct Personnel		0		0		0		0		0		0		0

A--ESCALATION FACTOR 7.9% FOR 85.

B--ESCALATION FACTOR 7.8% FOR FY 86; CONSTANT FY 86 DOLLARS AFTER FY 86.

RESOURCES BY SUB PROGRAM  
 ASSISTANT SECRETARY FOR ENERGY RESEARCH  
 (\$ IN MILLIONS - PERSONNEL IN FTE)

	FY84 BA	Actual Costs	A		B		FY 1987		FY 1988		FY 1989		FY 1990	
			FY 1985 BA	B0	FY 1986 BA	B0	BA	B0	BA	B0	BA	B0	BA	B0
ENERGY RESEARCH														
Total Operating	85.5	86.1	86.8	87.1	116.2	108.9	118.4	116.0	116.1	116.1	115.8	115.9	115.9	115.9
Capital Equipment	5.9	5.9	5.6	5.6	11.0	11.0	10.3	10.3	10.7	10.7	10.7	10.7	10.4	10.4
Construction	0.5	2.3	1.0	0.4	0.3	1.0	2.7	2.7	0.0	0.5	0.0	0.0	0.0	0.0
Total ER	91.9	94.3	93.4	93.1	127.5	120.9	131.4	128.6	126.8	127.3	126.5	126.6	126.3	126.3
Direct Personnel		790		792		884		943		943		943		943

Los Alamos

A--ESCALATION FACTOR 7.9% FOR 85.

B--ESCALATION FACTOR 7.8% FOR FY 86; CONSTANT FY 86 DOLLARS AFTER FY 86.

RESOURCES BY SUB PROGRAM  
 ASSISTANT SECRETARY FOR NUCLEAR ENERGY  
 (\$ IN MILLIONS - PERSONNEL IN FTE)

	FY84 Actual		A		B		FY 1987		FY 1988		FY 1989		FY 1990	
	BA	Costs	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
AE20 SPACE&TERR APPL														
Total Operating	5.5	5.7	6.8	6.8	11.1	10.0	12.0	11.5	11.5	11.5	11.5	11.5	11.5	11.5
Capital Equipment	0.2	0.2	0.2	0.2	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Construction	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
Subtotal	5.7	5.9	7.0	7.0	11.8	10.7	12.7	12.2	12.2	12.2	12.2	12.2	12.2	12.2
Direct Personnel		68		61		70		81		81		81		81
AE-ADV NUCLEAR SYSTEMS														
Total Operating	5.5	5.7	6.8	6.8	11.1	10.0	12.0	11.5	11.5	11.5	11.5	11.5	11.5	11.5
Capital Equipment	0.2	0.2	0.2	0.2	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Construction	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
Total AE	5.7	5.9	7.0	7.0	11.8	10.7	12.7	12.2	12.2	12.2	12.2	12.2	12.2	12.2
Direct Personnel		68		61		70		81		81		81		81
AF15 LMFBR BASE PGM														
Total Operating	10.7	10.1	8.0	8.0	5.6	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.3
Capital Equipment	0.0	0.0	0.0	0.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Construction	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
Subtotal	10.7	10.1	8.0	8.0	6.3	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	7.0
Direct Personnel		93		43		43		43		43		43		43
AF-BREEDER REACTORS														
Total Operating	10.7	10.1	8.0	8.0	5.6	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.3
Capital Equipment	0.0	0.0	0.0	0.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Construction	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
Total AF	10.7	10.1	8.0	8.0	6.3	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	7.0
Direct Personnel		93		43		43		43		43		43		43
AG15 ADV REACTOR SYSTEMS														
Total Operating	0.0	0.0	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Capital Equipment	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
Construction	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
Subtotal	0.0	0.0	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Direct Personnel		0		1		1		1		1		1		1
AG25														
Total Operating	0.1	0.1	0.1	0.1	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Capital Equipment	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
Construction	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
Subtotal	0.1	0.1	0.1	0.1	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Direct Personnel		1		2		2		2		2		2		2

A--ESCALATION FACTOR 7.9% FOR 85.

B--ESCALATION FACTOR 7.8% FOR FY 86; CONSTANT FY 86 DOLLARS AFTER FY 86.

RESOURCES BY SUB PROGRAM  
 ASSISTANT SECRETARY FOR NUCLEAR ENERGY  
 (\$ IN MILLIONS - PERSONNEL IN FTE)

	FY84 Actual		A		B		FY 1987		FY 1988		FY 1989		FY 1990		Los Alamos
	BA	Costs	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	
AG30 3 MILE ISLAND															
Total Operating	0.1	0.1	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
Capital Equipment	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	0.0
Construction	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	0.0
Subtotal	0.1	0.1	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
Direct Personnel		1		0		0		0		0		0		0	
AG36 LGT WATER REACT															
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	0.0
Capital Equipment	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	0.0
Construction	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	0.0
Subtotal	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	0.0
Direct Personnel		1		0		0		0		0		0		0	
AG-CONVERTER REACTORS															
Total Operating	0.2	0.3	0.7	0.7	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Capital Equipment	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	0.0
Construction	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	0.0
Total AG	0.2	0.3	0.7	0.7	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Direct Personnel		3		3		3		3		3		3		3	
AH10 REMEDIAL ACTION															
Total Operating	0.0	0.0	0.3	0.3	0.2	0.2	1.0	0.8	0.8	0.8	0.4	0.5	0.5	0.5	0.5
Capital Equipment	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	0.0
Construction	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	0.0
Subtotal	0.0	0.0	0.3	0.3	0.2	0.2	1.0	0.8	0.8	0.8	0.4	0.5	0.5	0.5	0.5
Direct Personnel		0		1		1		2		2		2		2	
AH-REMEDIAL ACTION PROGRAMS															
Total Operating	0.0	0.0	0.3	0.3	0.2	0.2	1.0	0.8	0.8	0.8	0.4	0.5	0.5	0.5	0.5
Capital Equipment	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	0.0
Construction	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	0.0
Total AH	0.0	0.0	0.3	0.3	0.2	0.2	1.0	0.8	0.8	0.8	0.4	0.5	0.5	0.5	0.5
Direct Personnel		0		1		1		2		2		2		2	
AS15 FUEL CYCLE R&D															
Total Operating	0.1	0.1	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
Capital Equipment	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	0.0
Construction	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	0.0
Subtotal	0.1	0.1	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
Direct Personnel		1		0		0		0		0		0		0	

A--ESCALATION FACTOR 7.9% FOR 85.

B--ESCALATION FACTOR 7.8% FOR FY 86; CONSTANT FY 86 DOLLARS AFTER FY 86.

RESOURCES BY SUB PROGRAM  
 ASSISTANT SECRETARY FOR NUCLEAR ENERGY  
 (\$ IN MILLIONS - PERSONNEL IN FTE)

	FY84 BA	Actual Costs	A		B		FY 1987		FY 1988		FY 1989		FY 1990	
			FY 1985 BA	BO	FY 1986 BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
AS-NUCLEAR FUEL CYCLE														
Total Operating	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	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
Construction	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
Total AS	0.1	0.1	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		0		0		0		0		0		0
CD10 URAN ENRICH ACT														
Total Operating	0.4	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
Capital Equipment	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
Construction	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
Subtotal	0.4	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		1		1		1		1		1		1		1
CD-URANIUM ENRICHMENT														
Total Operating	0.4	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
Capital Equipment	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
Construction	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
Total CD	0.4	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		1		1		1		1		1		1		1
NUCLEAR ENERGY														
Total Operating	16.9	16.3	16.0	16.0	17.5	17.0	19.8	19.1	19.1	19.1	18.7	18.8	18.8	18.9
Capital Equipment	0.2	0.2	0.2	0.2	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Construction	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
Total NE	17.1	16.5	16.2	16.2	18.9	18.4	21.2	20.5	20.5	20.5	20.1	20.2	20.2	20.3
Direct Personnel		166		109		118		130		130		130		130

A--ESCALATION FACTOR 7.9% FOR 85.

B--ESCALATION FACTOR 7.8% FOR FY 86; CONSTANT FY 86 DOLLARS AFTER FY 86.

RESOURCES BY SUB PROGRAM  
 ASSISTANT SECRETARY FOR CONSERVATION/RENEW ENERGY  
 (\$ IN MILLIONS - PERSONNEL IN FTE)

	FY84 BA	Actual Costs	A FY 1985		B FY 1986		FY 1987		FY 1988		FY 1989		FY 1990	
			BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
AL05 BATTERY STORAGE														
Total Operating	1.3	2.0	1.5	1.5	2.8	2.5	5.8	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Capital Equipment	0.1	0.1	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	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
Subtotal	1.4	2.1	1.7	1.7	2.8	2.5	5.8	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Direct Personnel		8		11		11		22		22		22		22
AL10 THERMAL MECH ST														
Total Operating	0.4	0.4	0.0	0.0	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.0
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.4
Construction	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
Subtotal	0.4	0.4	0.0	0.0	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.7	0.4
Direct Personnel		1		0		3		3		3		3		3
AL-ENERGY STORAGE SYSTEMS														
Total Operating	1.7	2.4	1.5	1.5	3.4	2.9	6.2	5.4	5.4	5.4	5.4	5.4	5.3	5.0
Capital Equipment	0.1	0.1	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.4
Construction	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
Total AL	1.8	2.5	1.7	1.7	3.4	2.9	6.2	5.4	5.4	5.4	5.4	5.4	5.7	5.4
Direct Personnel		9		11		14		25		25		25		25
AM10 GEOTHERMAL TECH														
Total Operating	7.7	7.3	7.2	8.6	6.5	7.0	1.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	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
Construction	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
Subtotal	7.7	7.3	7.2	8.6	6.5	7.0	1.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0
Direct Personnel		69		55		30		16		0		0		0
AM-GEOTHERMAL														
Total Operating	7.7	7.3	7.2	8.6	6.5	7.0	1.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	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
Construction	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
Total AM	7.7	7.3	7.2	8.6	6.5	7.0	1.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0
Direct Personnel		69		55		30		16		0		0		0
EB01 ACT/PASS SOLAR														
Total Operating	1.3	1.4	0.6	0.6	1.8	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Capital Equipment	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
Construction	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
Subtotal	1.3	1.4	0.6	0.6	1.8	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Direct Personnel		12		13		13		13		13		13		13

A--ESCALATION FACTOR 7.9% FOR 85.

B--ESCALATION FACTOR 7.8% FOR FY 86; CONSTANT FY 86 DOLLARS AFTER FY 86.

RESOURCES BY SUB PROGRAM  
 ASSISTANT SECRETARY FOR CONSERVATION/RENEW ENERGY  
 (\$ IN MILLIONS - PERSONNEL IN FTE)

	FY84 BA	Actual Costs	A		B		FY 1987		FY 1988		FY 1989		FY 1990	
			FY 1985 BA	B0	FY 1986 BA	B0	BA	B0	BA	B0	BA	B0	BA	B0
EB-SOLAR ENERGY														
Total Operating	1.3	1.4	0.6	0.6	1.8	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Capital Equipment	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
Construction	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
Total EB	1.3	1.4	0.6	0.6	1.8	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Direct Personnel		12		13		13		13		13		13		13
EC03 COMMUNITY SYS														
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
Capital Equipment	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
Construction	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
Subtotal	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		1		0		0		0		0		0		0
EC-BLDG & COMMUNITY SYSTEMS														
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
Capital Equipment	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
Construction	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
Total EC	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		1		0		0		0		0		0		0
ED02 LASER MOLTER STEEL SENS														
Total Operating	0.3	0.3	0.4	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Capital Equipment	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
Construction	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
Subtotal	0.3	0.3	0.4	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Direct Personnel		3		2		2		2		2		2		2
ED-INDUSTRIAL														
Total Operating	0.3	0.3	0.4	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Capital Equipment	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
Construction	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
Total ED	0.3	0.3	0.4	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Direct Personnel		3		2		2		2		2		2		2
EE03 ELECT VEHICLE														
Total Operating	0.1	0.2	0.2	0.2	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Capital Equipment	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
Construction	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
Subtotal	0.1	0.2	0.2	0.2	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Direct Personnel		2		1		3		3		3		3		3

A--ESCALATION FACTOR 7.9% FOR 85.

B--ESCALATION FACTOR 7.8% FOR FY 86; CONSTANT FY 86 DOLLARS AFTER FY 86.

RESOURCES BY SUB PROGRAM  
 ASSISTANT SECRETARY FOR CONSERVATION/RENEW ENERGY  
 (\$ IN MILLIONS - PERSONNEL IN FTE)

	FY84 BA	Actual Costs	A FY 1985		B FY 1986		FY 1987		FY 1988		FY 1989		FY 1990	
			BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
EE-TRANSPORTATION														
Total Operating	0.1	0.2	0.2	0.2	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Capital Equipment	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
Construction	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
Total EE	0.1	0.2	0.2	0.2	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Direct Personnel		2		1		3		3		3		3		3
EG05 ENERGY CNV TECH														
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	0.0	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
Construction	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
Subtotal	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
Direct Personnel		4		4		4		4		4		4		4
EG-MULTI SECTOR														
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	0.0	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
Construction	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
Total EG	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
Direct Personnel		4		4		4		4		4		4		4
CONSERVATION/RENEW ENERGY														
Total Operating	11.7	12.3	10.5	11.8	13.5	13.1	10.4	11.1	8.6	8.6	8.6	8.6	8.5	8.2
Capital Equipment	0.1	0.1	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.4
Construction	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
Total CE	11.9	12.4	10.7	12.0	13.5	13.1	10.4	11.1	8.6	8.6	8.6	8.6	8.9	8.6
Direct Personnel		100		86		66		63		47		47		47

A--ESCALATION FACTOR 7.9% FOR 85.

B--ESCALATION FACTOR 7.8% FOR FY 86; CONSTANT FY 86 DOLLARS AFTER FY 86.

RESOURCES BY SUB PROGRAM  
 ASSISTANT SECRETARY FOR FOSSIL ENERGY  
 (\$ IN MILLIONS - PERSONNEL IN FTE)

	FY84 Actual		A		B		FY 1987		FY 1988		FY 1989		FY 1990	
	BA	Costs	FY 1985 BA	BO	FY 1986 BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
AA05 CTRL TEC&COAL P														
Total Operating	0.1	0.1	0.0	0.0	1.1	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Capital Equipment	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
Construction	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
Subtotal	0.1	0.1	0.0	0.0	1.1	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Direct Personnel		1		1		5		5		5		5		5
AA15 ADV RES&TEC DEV														
Total Operating	0.9	1.0	0.6	0.5	1.2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Capital Equipment	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
Construction	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
Subtotal	0.9	1.0	0.6	0.5	1.2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Direct Personnel		9		4		9		9		9		9		9
AA45 FUEL CELLS														
Total Operating	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Capital Equipment	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
Construction	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
Subtotal	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Direct Personnel		2		2		1		1		1		1		1
AA85 SYS ENGR CNCPT														
Total Operating	0.4	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
Capital Equipment	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
Construction	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
Subtotal	0.4	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		3		0		0		0		0		0		0
AA-COAL														
Total Operating	1.6	1.6	0.8	0.7	2.3	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
Capital Equipment	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
Construction	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
Total AA	1.6	1.6	0.8	0.7	2.3	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
Direct Personnel		15		7		15		15		15		15		15
AB05 ENHANCED GAS RC														
Total Operating	0.4	0.3	0.6	0.5	0.5	0.5	0.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	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
Construction	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
Subtotal	0.4	0.3	0.6	0.5	0.5	0.5	0.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0
Direct Personnel		3		4		4		4		0		0		0

A--ESCALATION FACTOR 7.9% FOR 85.

B--ESCALATION FACTOR 7.8% FOR FY 86; CONSTANT FY 86 DOLLARS AFTER FY 86.

RESOURCES BY SUB PROGRAM  
 ASSISTANT SECRETARY FOR FOSSIL ENERGY  
 (\$ IN MILLIONS - PERSONNEL IN FTE)

	FY84 BA	Actual Costs	A		B		FY 1987		FY 1988		FY 1989		FY 1990	
			FY 1985 BA	B0	FY 1986 BA	B0	BA	B0	BA	B0	BA	B0	BA	B0
AB-GAS														
Total Operating	0.4	0.3	0.6	0.5	0.5	0.5	0.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	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
Construction	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
Total AB	0.4	0.3	0.6	0.5	0.5	0.5	0.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0
Direct Personnel		3		4		4		4		0		0		0
AC15 ENHANCED OIL RC														
Total Operating	0.1	0.2	0.0	0.0	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Capital Equipment	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
Construction	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
Subtotal	0.1	0.2	0.0	0.0	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Direct Personnel		1		0		2		2		2		2		2
AC20 OIL SHALE														
Total Operating	1.4	1.4	1.0	1.0	2.3	2.0	2.7	2.5	3.2	3.0	3.0	3.0	3.0	3.0
Capital Equipment	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
Construction	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
Subtotal	1.4	1.4	1.0	1.0	2.3	2.0	2.7	2.5	3.2	3.0	3.0	3.0	3.0	3.0
Direct Personnel		13		11		16		20		22		22		22
AC-PETROLEUM														
Total Operating	1.5	1.6	1.0	1.0	2.6	2.2	2.9	2.7	3.4	3.2	3.2	3.2	3.2	3.2
Capital Equipment	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
Construction	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
Total AC	1.5	1.6	1.0	1.0	2.6	2.2	2.9	2.7	3.4	3.2	3.2	3.2	3.2	3.2
Direct Personnel		14		11		18		22		24		24		24
CV02 ENH GAS RECOV														
Total Operating	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Capital Equipment	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
Construction	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
Subtotal	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Direct Personnel		0		0		1		1		1		1		1
CV-OIL AND GAS DEV PROJ														
Total Operating	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Capital Equipment	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
Construction	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
Total CV	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Direct Personnel		0		0		1		1		1		1		1

Los Alamos

A--ESCALATION FACTOR 7.9% FOR 85.

B--ESCALATION FACTOR 7.8% FOR FY 86; CONSTANT FY 86 DOLLARS AFTER FY 86.

RESOURCES BY SUB PROGRAM  
 ASSISTANT SECRETARY FOR FOSSIL ENERGY  
 (\$ IN MILLIONS - PERSONNEL IN FTE)

	FY84 Actual		A FY 1985		B FY 1986		FY 1987		FY 1988		FY 1989		FY 1990	
	BA	Costs	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
FOSSIL ENERGY														
Total Operating	3.5	3.5	2.4	2.2	5.5	4.7	5.4	5.2	5.4	5.2	5.2	5.2	5.2	5.2
Capital Equipment	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
Construction	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
Total FE	3.5	3.5	2.4	2.2	5.5	4.7	5.4	5.2	5.4	5.2	5.2	5.2	5.2	5.2
Direct Personnel		32		22		38		42		40		40		40

A--ESCALATION FACTOR 7.9% FOR 85.

B--ESCALATION FACTOR 7.8% FOR FY 86; CONSTANT FY 86 DOLLARS AFTER FY 86.

RESOURCES BY SUB PROGRAM  
 ASSISTANT SECRETARY FOR POLICY/SAFETY/ENV.  
 (\$ IN MILLIONS - PERSONNEL IN FTE)

	FY84 BA	Actual Costs	A		B		FY 1987		FY 1988		FY 1989		FY 1990	
			FY 1985 BA	B0	FY 1986 BA	B0	BA	B0	BA	B0	BA	B0	BA	B0
HA01 OVERVIEW/ASSMT														
Total Operating	1.4	1.7	2.0	2.0	3.2	2.9	3.3	3.2	3.5	3.4	3.7	3.6	3.6	3.6
Capital Equipment	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Construction	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
Subtotal	1.5	1.8	2.1	2.1	3.4	3.1	3.5	3.4	3.7	3.6	3.9	3.8	3.8	3.8
Direct Personnel		17		18		24		26		28		29		29
HA-ENVIRONMENTAL R&D														
Total Operating	1.4	1.7	2.0	2.0	3.2	2.9	3.3	3.2	3.5	3.4	3.7	3.6	3.6	3.6
Capital Equipment	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Construction	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
Total HA	1.5	1.8	2.1	2.1	3.4	3.1	3.5	3.4	3.7	3.6	3.9	3.8	3.8	3.8
Direct Personnel		17		18		24		26		28		29		29
PE01 PLCY, PLAN&ANAL														
Total Operating	0.3	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Capital Equipment	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
Construction	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
Subtotal	0.3	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Direct Personnel		0		3		3		3		3		3		3
PE-POLICY ANAL & SYS STUDIES														
Total Operating	0.3	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Capital Equipment	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
Construction	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
Total PE	0.3	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Direct Personnel		0		3		3		3		3		3		3
UF04 ENERGY VUL.														
Total Operating	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	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
Construction	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
Subtotal	0.0	0.1	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		0		0		0		0		0		0
UF-ENVIRON EMERGENCY PREP														
Total Operating	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	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
Construction	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
Total UF	0.0	0.1	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		0		0		0		0		0		0

A--ESCALATION FACTOR 7.9% FOR 85.

B--ESCALATION FACTOR 7.8% FOR FY 86; CONSTANT FY 86 DOLLARS AFTER FY 86.

RESOURCES BY SUB PROGRAM  
 ASSISTANT SECRETARY FOR POLICY/SAFETY/ENV.  
 (\$ IN MILLIONS - PERSONNEL IN FTE)

	FY84 Actual		A		B		FY 1987		FY 1988		FY 1989		FY 1990	
	BA	Costs	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
POLICY/SAFETY/ENV.														
Total Operating	1.7	2.0	2.4	2.4	3.5	3.2	3.6	3.5	3.8	3.7	4.0	3.9	3.9	3.9
Capital Equipment	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Construction	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
Total PE	1.8	2.1	2.5	2.5	3.7	3.4	3.8	3.7	4.0	3.9	4.2	4.1	4.1	4.1
Direct Personnel		18		21		27		29		31		32		32

A--ESCALATION FACTOR 7.9% FOR 85.

B--ESCALATION FACTOR 7.8% FOR FY 86; CONSTANT FY 86 DOLLARS AFTER FY 86.

RESOURCES BY SUB PROGRAM  
 ASSISTANT SECRETARY FOR INT AFFAIRS/ENERGY EMERG  
 (\$ IN MILLIONS - PERSONNEL IN FTE)

	FY84 BA	Actual Costs	A		B		FY 1987		FY 1988		FY 1989		FY 1990	
			FY 1985 BA	BO	FY 1986 BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
NA02 INTL POLICY STD														
Total Operating	0.0	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
Capital Equipment	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
Construction	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
Subtotal	0.0	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
Direct Personnel		0		1		1		1		1		1		1
NA-INTERNATIONAL AFFAIRS														
Total Operating	0.0	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
Capital Equipment	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
Construction	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
Total NA	0.0	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
Direct Personnel		0		1		1		1		1		1		1
INT AFFAIRS/ENERGY EMERG														
Total Operating	0.0	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
Capital Equipment	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
Construction	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
Total IA	0.0	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
Direct Personnel		0		1		1		1		1		1		1

Los Alamos

A--ESCALATION FACTOR 7.9% FOR 85.

B--ESCALATION FACTOR 7.8% FOR FY 86; CONSTANT FY 86 DOLLARS AFTER FY 86.

RESOURCES BY SUB PROGRAM  
 ASSISTANT SECRETARY FOR MANAGEMENT & ADMINISTRATION  
 (\$ IN MILLIONS - PERSONNEL IN FTE)

	FY84 BA	Actual Costs	A		B		FY 1987		FY 1988		FY 1989		FY 1990	
			FY 1985 BA	BO	FY 1986 BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
WB00 ENERGY MGMNT														
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
Capital Equipment	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
Construction	0.0	0.0	0.0	0.0	1.8	0.7	5.8	6.8	0.0	0.1	0.0	0.0	0.0	0.0
Subtotal	0.2	0.2	0.0	0.0	1.8	0.7	5.8	6.8	0.0	0.1	0.0	0.0	0.0	0.0
Direct Personnel		0		0		0		0		0		0		0
WB-IN-HOUSE ENERGY MGT														
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
Capital Equipment	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
Construction	0.0	0.0	0.0	0.0	1.8	0.7	5.8	6.8	0.0	0.1	0.0	0.0	0.0	0.0
Total WB	0.2	0.2	0.0	0.0	1.8	0.7	5.8	6.8	0.0	0.1	0.0	0.0	0.0	0.0
Direct Personnel		0		0		0		0		0		0		0
MANAGEMENT & ADMINISTRATION														
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
Capital Equipment	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
Construction	0.0	0.0	0.0	0.0	1.8	0.7	5.8	6.8	0.0	0.1	0.0	0.0	0.0	0.0
Total MA	0.2	0.2	0.0	0.0	1.8	0.7	5.8	6.8	0.0	0.1	0.0	0.0	0.0	0.0
Direct Personnel		0		0		0		0		0		0		0

A--ESCALATION FACTOR 7.9% FOR 85.

B--ESCALATION FACTOR 7.8% FOR FY 86; CONSTANT FY 86 DOLLARS AFTER FY 86.

RESOURCES BY SUB PROGRAM  
 NUCLEAR WASTE POLICY ACT PROJECT OFFICE  
 (\$ IN MILLIONS - PERSONNEL IN FTE)

	FY84 BA	Actual Costs	A		B		FY 1987		FY 1988		FY 1989		FY 1990	
			FY 1985 BA	BO	FY 1986 BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
DB30 NUCL WASTE FUND														
Total Operating	9.3	9.3	0.0	10.1	12.8	12.1	11.2	11.4	6.6	7.8	6.3	6.7	6.7	6.7
Capital Equipment	0.2	0.2	1.3	1.3	1.8	1.8	1.4	1.4	0.5	0.5	0.5	0.5	0.5	0.5
Construction	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
Subtotal	9.5	9.5	1.3	11.4	14.6	13.9	12.6	12.8	7.1	8.3	6.8	7.2	7.2	7.2
Direct Personnel		80		74		80		70		49		43		43
DB-NUCLEAR WASTE FUND														
Total Operating	9.3	9.3	0.0	10.1	12.8	12.1	11.2	11.4	6.6	7.8	6.3	6.7	6.7	6.7
Capital Equipment	0.2	0.2	1.3	1.3	1.8	1.8	1.4	1.4	0.5	0.5	0.5	0.5	0.5	0.5
Construction	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
Total DB	9.5	9.5	1.3	11.4	14.6	13.9	12.6	12.8	7.1	8.3	6.8	7.2	7.2	7.2
Direct Personnel		80		74		80		70		49		43		43
NUCLEAR WASTE PAPO														
Total Operating	9.3	9.3	0.0	10.1	12.8	12.1	11.2	11.4	6.6	7.8	6.3	6.7	6.7	6.7
Capital Equipment	0.2	0.2	1.3	1.3	1.8	1.8	1.4	1.4	0.5	0.5	0.5	0.5	0.5	0.5
Construction	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
Total NW	9.5	9.5	1.3	11.4	14.6	13.9	12.6	12.8	7.1	8.3	6.8	7.2	7.2	7.2
Direct Personnel		80		74		80		70		49		43		43

A--ESCALATION FACTOR 7.9% FOR 85.

B--ESCALATION FACTOR 7.8% FOR FY 86; CONSTANT FY 86 DOLLARS AFTER FY 86.

RESOURCES BY SUB PROGRAM  
 WORK FOR OTHERS  
 (\$ IN MILLIONS - PERSONNEL IN FTE)

	FY84 Actual		A		B		FY 1987		FY 1988		FY 1989		FY 1990	
	BA	Costs	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
WFO - DOE														
Total Operating	27.4	27.4	28.7	28.7	26.1	26.1	26.5	26.5	31.3	31.3	31.3	31.3	31.3	31.3
Capital Equipment	0.0	0.0	1.6	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	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
Subtotal	27.4	27.4	30.3	30.3	26.1	26.1	26.5	26.5	31.3	31.3	31.3	31.3	31.3	31.3
Direct Personnel		232		278		235		238		282		282		282
TOTAL DOE														
Total Operating	530.8	533.2	553.9	550.4	661.7	633.0	632.1	632.5	627.9	629.5	629.5	629.5	629.4	629.2
Capital Equipment	33.3	33.3	32.8	32.8	66.7	66.7	59.3	59.3	59.2	59.2	59.5	59.5	60.7	60.7
Construction	31.2	37.5	49.2	50.8	74.3	64.8	151.7	152.7	71.2	94.1	50.0	44.0	20.0	21.0
Subtotal	595.3	604.0	635.9	634.0	802.7	764.5	843.1	844.5	758.3	782.8	739.0	733.0	710.1	710.9
Direct Personnel		4229		4266		4349		4339		4325		4330		4330

A--ESCALATION FACTOR 7.9% FOR 85.

B--ESCALATION FACTOR 7.8% FOR FY 86; CONSTANT FY 86 DOLLARS AFTER FY 86.

RESOURCES BY SUB PROGRAM  
WORK FOR OTHERS  
(\$ IN MILLIONS - PERSONNEL IN FTE)

	FY84 BA	Actual Costs	A		B		FY 1987		FY 1988		FY 1989		FY 1990	
			FY 1985 BA	BO	FY 1986 BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
WFO - NON DOE - DOD														
Total Operating	49.4	49.4	49.0	49.0	55.0	55.0	61.0	61.0	61.0	61.0	61.0	61.0	61.0	61.0
Capital Equipment	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
Construction	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
Subtotal	49.4	49.4	49.0	49.0	55.0	55.0	61.0	61.0	61.0	61.0	61.0	61.0	61.0	61.0
Direct Personnel		361		314		325		336		336		336		336
WFO - NON DOE - NRC														
Total Operating	15.1	14.3	12.6	12.6	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
Capital Equipment	0.2	0.2	0.5	0.5	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Construction	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
Subtotal	15.3	14.5	13.1	13.1	13.3	13.3	13.2	13.2	13.2	13.2	13.2	13.2	13.2	13.2
Direct Personnel		114		92		92		92		92		92		92
WFO NON-DOE														
Total Operating	21.5	21.5	25.9	25.9	24.5	24.5	24.5	24.5	26.4	26.4	25.7	25.7	25.7	25.7
Capital Equipment	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
Construction	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
Subtotal	21.5	21.5	25.9	25.9	24.5	24.5	24.5	24.5	26.4	26.4	25.7	25.7	25.7	25.7
Direct Personnel		172		198		174		173		187		182		182
WFO-WORK FOR OTHERS														
Total Operating	113.4	112.6	116.2	116.2	118.6	118.6	125.0	125.0	131.7	131.7	131.0	131.0	131.0	131.0
Capital Equipment	0.2	0.2	2.1	2.1	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Construction	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
Subtotal	113.6	112.8	118.3	118.3	118.9	118.9	125.2	125.2	131.9	131.9	131.2	131.2	131.2	131.2
Direct Personnel		879		882		826		839		897		892		892

A--ESCALATION FACTOR 7.9% FOR 85.

B--ESCALATION FACTOR 7.8% FOR FY 86; CONSTANT FY 86 DOLLARS AFTER FY 86.

RESOURCES BY SUB PROGRAM  
LABORATORY TOTAL  
(\$ IN MILLIONS - PERSONNEL IN FTE)

	FY84 Actual		A FY 1985		B FY 1986		FY 1987		FY 1988		FY 1989		FY 1990	
	BA	Costs	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
LABORATORY TOTAL														
Total Operating	616.8	618.4	641.4	637.9	754.2	725.5	730.6	731.0	728.3	731.0	729.2	729.2	729.1	728.9
Capital Equipment	33.5	33.5	33.3	33.3	67.0	67.0	59.5	59.5	59.4	59.4	59.7	59.7	60.9	60.9
Construction	31.2	37.5	49.2	50.8	74.3	64.8	151.7	152.7	71.2	94.1	50.0	44.0	20.0	21.0
Total Funding	681.5	689.4	723.9	722.0	895.5	857.3	941.8	943.2	858.9	884.5	838.9	832.9	810.0	810.8
Direct Personnel		4876		4870		4940		4940		4940		4940		4940

A--ESCALATION FACTOR 7.9% FOR 85.

B--ESCALATION FACTOR 7.8% FOR FY 86; CONSTANT FY 86 DOLLARS AFTER FY 86.

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## IX. ORGANIZATIONAL CHART

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# Los Alamos National Laboratory

## IX. ORGANIZATIONAL CHART

