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Volume 3 of 7

Congressional Budget Request

Energy Supply Research and Development

Volume 3

FY 1987

U.S. Department of Energy
Assistant Secretary,
Management and Administration
Office of the Controller
Washington, D.C. 20585

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DEPARTMENT OF ENERGY

FISCAL YEAR 1987 CONGRESSIONAL BUDGET REQUEST

ENERGY SUPPLY RESEARCH AND DEVELOPMENT

VOLUME 3

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DEPARTMENT OF ENERGY

FISCAL YEAR 1987 CONGRESSIONAL BUDGET REQUEST

SUMMARY OF ESTIMATES BY APPROPRIATIONS

(in thousands of dollars)

	FY 1985 Actual BA	FY 1986 Estimate BA	FY 1987 Request BA
Appropriations Before The Energy and Water Development Subcommittees:			
Energy Supply Research and Development	1,967,490	1,696,298	1,254,162
Uranium Enrichment	237,956	190,512	---
General Science and Research	724,860	655,928	773,400
Atomic Energy Defense Activities	7,322,321	7,231,664	8,230,000
Departmental Administration	128,602	150,319	151,082
Alaska Power Administration	3,233	3,245	2,881
Bonneville Power Administration	284,771	330,000	276,100
Southeastern Power Administration	35,744	---	19,647
Southwestern Power Administration	31,208	29,191	25,337
Western Area Power Administration	218,230	195,910	240,309
Western Area Power Emergency Fund	---	---	---
Federal Energy Regulatory Commission	54,543	41,989	20,325
Nuclear Waste Fund	327,669	499,037	769,349
Geothermal Resources Development Fund	121	69	72
Subtotal, Appropriations Before the Energy and Water Development Subcommittees	$11,336,748	$11,024,162	$11,762,664

DEPARTMENT OF ENERGY

FISCAL YEAR 1987 CONGRESSIONAL BUDGET REQUEST

SUMMARY OF ESTIMATES BY APPROPRIATIONS

(in thousands of dollars)

	FY 1985 Actual BA	FY 1986 Estimate BA	FY 1987 Request BA
Appropriations Before Interior and Related Agencies Subcommittees:			
Alternative Fuels Production	$ 1,169,895	$ ---	$ ---
Clean Coal Technology	---	---	---
Fossil Energy Research and Development	289,048	311,954	82,767
Naval Petroleum and Oil Shale Reserves	156,874	13,002	127,108
Energy Conservation	457,436	427,512	39,433
Energy Regulation	27,139	23,423	21,850
Emergency Preparedness	6,045	5,750	6,044
Strategic Petroleum Reserve	2,049,550	107,533	---
Energy Information Activities	60,919	57,724	59,651
Subtotal, Interior and Related Agencies Subcommittees	4,216,906	946,898	336,853
Subtotal, Energy and Water Development Subcommittees	11,336,748	11,024,162	11,762,664
Subtotal, Department of Energy	15,553,654	11,971,060	12,099,517
Permanent - Indefinite Appropriations:			
Payments to States	1,052	570	570
Total, Department of Energy	$15,554,706	$11,971,630	$12,100,087

Department of Energy
FY 1987 Congressional Staffing Request
Total Work Force

	FY1985 FTE USAGE	FY1986 CONGR REQ	FY1987 -FY86	FY1987 CONGR REQ
ENERGY & WATER SUBCOMMITTEE				
HEADQUARTERS	4,865	4,965	-18	4,947
FIELD	9,133	9,185	111	9,296
SUBCOMMITTEE TOTAL	13,998	14,150	93	14,243
INTERIOR SUBCOMMITTEE				
HEADQUARTERS	1,353	1,304	-166	1,138
FIELD	907	896	-226	670
SUBCOMMITTEE TOTAL	2,260	2,200	-392	1,808
GRAND TOTAL	16,258	16,350	-299	16,051
ADJUSTMENT		-132	-198	-330
ADJUSTED TOTAL	16,258	16,218	-497	15,721

Department of Energy
F Y 1987 Congressional Staffing Request
Total Work Force

	FY1985 FTE USAGE	FY1986 CONGR REQ	FY1987 -FY86	FY1987 CONGR REQ
10:ENERGY SUPPLY RESEARCH AND DEV	937	934	-34	900
HEADQUARTERS	811	820	-28	792
FIELD	126	114	-6	108
15:URANIUM ENRICHMENT	69	66	1	67
HEADQUARTERS	58	55	1	56
FIELD	11	11	0	11
20:GENERAL SCIENCE AND RESEARCH	37	39	0	39
HEADQUARTERS	37	39	0	39
25:ATOMIC ENERGY DEFENSE ACTIVITI	2,618	2,702	131	2,833
HEADQUARTERS	496	518	9	527
FIELD	2,122	2,184	122	2,306
30:DEPARTMENTAL ADMINISTRATION	3,307	3,332	-5	3,327
HEADQUARTERS	1,721	1,726	0	1,726
FIELD	1,586	1,606	-5	1,601
34:ALASKA POWER ADMINISTRATION	37	38	0	38
FIELD	37	38	0	38
36:BONNEVILLE POWER ADMIN	3,510	3,480	0	3,480
FIELD	3,510	3,480	0	3,480
38:SOUTHEASTERN POWER ADMIN	38	40	0	40
FIELD	38	40	0	40
42:SOUTHWESTERN POWER ADMIN	186	186	0	186
FIELD	186	186	0	186
46:WESTERN AREA POWER ADMIN	1,161	1,160	0	1,160
FIELD	1,161	1,160	0	1,160
50:WAPA - COLORADO RIVER BASIN	219	219	0	219
FIELD	219	219	0	219
52:FEDERAL ENERGY REGULATORY COMM	1,617	1,659	0	1,659
HEADQUARTERS	1,617	1,659	0	1,659
54:NUCLEAR WASTE FUND	238	292	0	292
HEADQUARTERS	123	147	0	147
FIELD	115	145	0	145
56:GEOTHERMAL RESOURCES DEV FUND	2	1	0	1
HEADQUARTERS	2	1	0	1
65:FOSSIL ENERGY RESEARCH AND DEV	714	700	-161	539
HEADQUARTERS	151	135	-26	109
FIELD	563	565	-135	430
70:NAVAL PETROL & OIL SHALE RES	104	104	-9	95
HEADQUARTERS	23	23	0	23
FIELD	81	81	-9	72
75:ENERGY CONSERVATION	333	352	-134	218
HEADQUARTERS	208	227	-79	148
FIELD	125	125	-55	70
80:EMERGENCY PREPAREDNESS	74	71	0	71
HEADQUARTERS	74	71	0	71
81:ECONOMIC REGULATION	377	340	-50	290
HEADQUARTERS	377	340	-50	290
85:STRATEGIC PETROLEUM RESERVE	178	152	-32	120
HEADQUARTERS	40	27	-5	22
FIELD	138	125	-27	98
90:ENERGY INFORMATION ACTIVITIES	480	481	-6	475
HEADQUARTERS	480	481	-6	475
94:ADVANCES FOR CO-OP WORK	2	2	0	2
FIELD	2	2	0	2
GRAND TOTAL	16,258	16,350	-299	16,051
ADJUSTMENT		-132	-198	-330
ADJUSTED TOTAL	16,258	16,218	-497	15,721

DEPARTMENT OF ENERGY

Proposed Appropriation Language

Energy Supply, Research and Development Activities

(Including Transfer of Funds)

For expenses of the Department of Energy activities including the purchase, construction and acquisition of plant and capital equipment and other expenses incidental thereto necessary for energy supply, research and development activities, and other activities in carrying out the purposes of the Department of Energy Organization Act (Public Law 95-91), including the acquisition or condemnation of any real property or any facility or for plant or facility acquisition, construction or expansion; purchase of passenger motor vehicles (not to exceed [17] 18 for replacement only), [$1,989,671,000] $1,254,162, to remain available until expended [of which $200,000,000]; in addition, $584,158,000 shall be derived by transfer from Uranium Supply and Enrichment Activities provided in prior years[, and of which $17,400,000 shall be derived by transfer from Operation and Maintenance, Southeastern Power Administration; and of which $25,000,000 shall be available only for construction of]: Provided, That funds available under this head in Public Law 99-141 for the Advanced Science Center, the Center for Science and Technology, the Center for Energy and Biomedical Technology, the Energy and Mineral Research Center, and the Demonstration Center for Information Technologies [as described in the report accompanying this Act; together with not to exceed $6,000,000, to be derived from revenues from activities of the Technical Information Services, which shall be credited to this account and used for necessary expenses and shall remain available until expended], shall be available for other expenses of energy supply, research and development activities. (Public Law 99-141, making appropriations for energy and water development, 1986.)

DEPARTMENT OF ENERGY

FISCAL YEAR 1987 CONGRESSIONAL BUDGET REQUEST

SUMMARY OF ESTIMATES BY APPROPRIATION BY MAJOR ACTIVITY

ENERGY SUPPLY RESEARCH AND DEVELOPMENT

(Budget Authority in Thousands of Dollars)

	FY 1985 Actual	FY 1986 Estimate	FY 1987 Request
Solar Energy	$ 171,587	$ 144,624	$ 72,292
Geothermal	29,698	26,681	17,930
Hydropower	447	481	---
Electric Energy Systems	19,717	11,548	7,619
Energy Storage Systems	18,642	17,292	8,008
Nuclear Energy R&D	412,612	375,684	330,900
Remedial Action & Waste Technology	170,365	230,047	294,100
Civilian Waste R&D	25,886	16,864	6,500
Environmental, Safety and Health	38,053	46,921	76,098
Biological and Environmental Research	187,746	179,950	196,565
Liquified Gaseous Spill Test Facility	4,289	1,732	1,200
Magnetic Fusion	429,653	365,469	333,000
Basic Energy Sciences	410,888	433,770	441,370
Energy Research Analysis	2,970	2,598	3,550
University Research Instrumentation	4,950	6,254	5,000
University Research Support	10,059	10,296	10,975
Advisory and Oversight Program Direction	2,900	2,674	2,900
Multi-Program Laboratories Facilities Support	33,200	39,824	60,190
Small Business Innovation Research Program	24,724	---	---
In-House Energy Management	14,821	11,709	16,500
Technical Information and Management	13,442	12,413	10,775
Policy and Management	3,380	3,497	3,887
Subtotal, Energy Supply R&D	2,029,690	1,939,528	1,899,951
Less Use of Prior Year Balances and Other Adjustment	-62,400	-243,230	-645,789
Total, Energy Supply R&D	$1,967,490	$1,696,298	$1,254,162

BIOLIGICAL AND ENVIRONMENTAL RESEARCH

DEPARTMENT OF ENERGY

FISCAL YEAR 1987 CONGRESSIONAL BUDGET REQUEST

ENERGY SUPPLY RESEARCH AND DEVELOPMENT

VOLUME 3

BIOLOGICAL AND ENVIRONMENTAL RESEARCH

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DEPARTMENT OF ENERGY
1987 CONGRESSIONAL BUDGET REQUEST
PROGRAM OVERVIEW

Biological and Environmental Research

The budget request for FY 1987 for the Biological and Environmental Research (BER) program is $196,565,000. Within this budget, $184,565,000 is for operating expenses, $8,500,000 for capital equipment, and $3,500,000 for construction. This request will allow continuation of the current year program activities and enhanced efforts on the health effects of environmental radon.

The mission of the Department of Energy in energy research and national defense has brought with it major responsibilities and opportunities in the life sciences. The responsibilities stem from concerns that the energy technologies which contribute so substantially to the material well being of the American people, may also have adverse health and environmental impacts. The opportunities arise because many of these same technologies, and the intellectual and physical resources underlying their development, have made major contributions to the health and welfare of society, and hold promise for even greater contributions in the future. Thus opportunities and danger are both present, and a central goal of the Biological and Environmental Research program (BER) is to maximize the former while helping to minimize the latter.

A central objective of the Department's health and environmental effects research is to create a knowledge base that will permit a realistic assessment of the impact of energy strategies before they are adopted. The accumulation of such knowledge requires long term research that is comprehensive and multidisciplinary in its scope, and quantitative and mechanistic in its level of understanding. Health and environmental effects research sponsored by the Department and its predecessor agencies has ranged from pioneering molecular investigations of such fundamentally important processes as DNA damage repair mechanisms, through systemic studies such as those that provided the earliest information on bone marrow transplantation, to the investigation of global processes that govern atmospheric transport.

These studies, and many others like them, were originally motivated by an effort to understand the effects of radiation on human health, and the mechanisms by which radionuclides move through the environment and the food chain. They have, however, had consequences which far exceed the original programmatic goals. Thus, the ability to identify and quantitate repair enzymes has led to major new insights into the genetic determinants of susceptibility to certain types of cancer with the discovery of increased risk in deficient populations. Research of this type, on molecular markers for susceptibility and resistance, is spawning a major subfield of molecular biology. Similarly, the basic research on bone marrow transplantation has provided much of the information upon which modern organ transplantation rests; while the research on atmospheric physics and chemistry has turned out to be central to approaching problems such as acid rain and changes in the atmospheric concentration of "greenhouse" molecules, which are currently of major concern to society.

Research in molecular epidemiology on understanding the molecular basis of diathesis and resistance to damage by radiation and toxic chemicals, will receive increased emphasis. The identification of populations that are particularly susceptible or resistant to certain types of insults is not only of the greatest significance to medical sciences, but it will have a major positive impact on the Department's mission by permitting an approach to setting health standards that takes account of population heterogeneity at the doses to which human populations are ordinarily exposed. Similarly, the extraordinarily high quality research on atmospheric

processes, which is providing the insights needed to develop optimal strategies for addressing energy related and national defense problems, will be strengthened. Other environmental programs also require strong support as evidenced by the large number of recently published reports that describe the health and environmental issues of the day. These are most comprehensively discussed in the Report on Long Term Environmental Research and Development of the Council of Environmental Quality (March 1985). For example, models of transport and chemical reaction in soil are crucial to rational decisions related to citings of toxic waste dumps and to optimal decisions on mitigation measures to correct past mistakes. The difference between optimal strategies based on knowledge gained through research, and far from optimal strategies, amounts to hundreds of billions of dollars in economic and health costs.

One of the extraordinary characteristics of the BER program is its comprehensiveness: the global nature of its scope--compelled by its mission--is unique to the nation and perhaps to the world. This breadth makes it ideally suited to carry out certain types of programs. An example of immediate societal concern is radon research. Recent information indicates that the potential exposures to radon gas and its daughter products in residential structures, and the number of people so exposed, may by substantial. A precise definition of the risk to health presented by these exposures, and the formulation of a rational strategy for the abatement of the risk, requires the entire spectrum of activities sponsored by the BER program. Thus, fully addressing the issue of radon health effects will require the development and testing of models of radon transport through the environment, carefully controlled epidemiological studies, and fundamental studies of the mechanisms by which radon produces damage. The first of these will permit the prediction of indoor radon levels and its state of aggregation from measurements exterior to a home; the latter two will provide information on the risk associated with a given level of radon.

This brief description indicates that the BER programs aimed at addressing the health and environmental impacts of energy strategies have led to fundamental scientific advances with major implications for human health and the economy that far exceed the goal of identifying potential hazards. There is, however, an additional and equally important component to the program's goal that is related to the unique capabilities of the Department of Energy.

The Department, by virtue of its role in the physical and engineering sciences, has extraordinary interdisciplinary capabilities, and unique capital intensive equipment. These capabilities have been widely recognized. In FY 1985, other Federal, state, and local agencies and private industry invested over $115,000,000 at these facilities for the conduct of health and environmental research to help address their mission needs. Many BER-funded scientists in the onsite laboratory program also hold academic appointments and serve as an important resource in the formal education of the nation's scientists, engineers, and physicians. The research projects supported at the laboratories and universities serve as vehicles for the training of hundreds of predoctoral students and post-doctoral investigators. Opportunities are provided for research collaboration by full-time visiting scientists. Finally, the unique facilities and research instrumentation annually attracts over 600 part-time users from the scientific community.

This combination of unrivaled physical and intellectual resources has led to major advances in medicine, and holds promise for equally important contributions in the future, both in medicine and biology. Historically, the focus has been on nuclear medicine: the development and application of non-invasive imaging techniques for diagnosis and treatment of disease, and the production of radionuclides and radiopharmaceuticals for the treatment ofptumors, and for the study of metabolic and other kinetic processes. Through collaborative programs with university and private

hospitals, applications are pursued through the clinical feasibility stage, and into the technology transfer process. The advances made in this way have helped cure or alleviate the sufferings of hundreds of thousands of people throughout the world and have spawned industries with markets valued at hundreds of millions of dollars per year. For example, Thallium 201 alone was administered to several hundred thousand patients in 1981 for the diagnosis of heart disease and its use has saved over $78,000,000 per year in medical expenses.

The future is equally promising with such new developments as magnetoencephalography which will permit the study of neurological processes with previously unattainable precision; with the promise of neutron capture therapy for treating cancer, and with the spectacular success of heavy ion therapy for curing small and otherwise untreatable brain lesions. Important new approaches are also being pursed which show great promise for the prevention and treatment of ischemic heart disease by measuring subtle changes in regional metabolism of heart muscle before and after interruption of coronary bloodflow.

Another development which emerged from the nuclear industry is the cell sorter; an instrument originally intended to separate radiation damaged cells from normal cells. Its impact has, however, far exceed the most optimistic justifications for its development. Rapid cell sorting capabilities have had a major impact on cytology, immunology and cell biology in general and have spawned a major new industry. Among its routine uses are blood cell counts, detecting genetic abnormalities and monitoring cancer treatment. More recently, improvements in the method have permitted the creation of a chromosome specific DNA library which scientists believe will advance the course of human genetics by a decade; an advance which will certainly be a major step forward in the diagnosis and treatment of genetic diseases.

Numerous other examples of major achievements in measurement concepts and devices, originally motivated by highly circumscribed needs, have been documented in a recent BER publication. Their impact on medicine, biology and the environmental sciences have been substantial; their impact on the economy alone more than pays back the cost to the taxpayers of the BER program and its predecessors.

In addition to the intellectual and scientific resources which have made these technologies possible, the national laboratories possess multiuser facilities that are having a major impact on elucidating the structure of biological molecules. Such structural determinations are required for a rational approach to a variety of molecular design problems; e.g., the modification of proteins so that they have a specified type of activity. Moreover, the unparalleled computational resources and the broad capability to exploit them fully, also provide the environment necessary for major advances in predictive capability for small molecule structure-activity relations, which is central to problems in identification of mutagens and carcinogens, and the design of drugs and vaccines. The development of rational approaches to drug design and protein engineering can lead to commercial markets with enormous health and economic impact. Together, these structural biology activities will provide the firm foundation crucial to maintaining America's competitive advantage in private sector biotechnology during the coming decades.

The BER program budget request includes funds to support 89 FTE's at the Environmental Measurements Laboratory. The staff are Federal employees doing research in the areas of ecology, instrumentation and analytical development. This is a Government-owned, Government-operated facility, with complete laboratory capabilities.

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
BIOLOGICAL AND ENVIRONMENTAL RESEARCH
ENVIRONMENTAL R&D
ENERGY SUPPLY RESEARCH AND DEVELOPMENT
(Tabular dollars in thousands. Narrative material in whole dollars.)

	FY 1985 Appropriation	FY 1986 Appropriation	FY 1987 Base	FY 1987 Request	Request vs Base
Environmental R&D					
Operating Expenses					
Biological and Environmental Research	$174,405	$166,237	$166,237	$180,965	$+14,728
Program Direction.....	3,475	3,129	3,129	3,600	+ 471
Subtotal.....	177,880	169,366	169,366	184,565	+15,199
Capital Equipment.....	7,141	7,457	7,457	8,500	+ 1,043
Subtotal.....	7,141	7,457	7,457	8,500	+ 1,043
Construction.....	2,725	3,127	3,127	3,500	+ 373
Subtotal.....	2,725	3,127	3,127	3,500	+ 373
Total					
Operating Expenses.....	177,880	169,366	169,366	184,565	+15,199
Capital Equipment.....	7,141	7,457	7,457	8,500	+ 1,043
Construction.....	2,725	3,127	3,127	3,500	+ 373
Environmental R&D.....	$187,746[a/][b/]	$179,950[b/][c/]	$179,950[b/][c/]	$196,565	$+16,615
Staffing Total FTE's:					
Headquarters.....	53	53	53	53	---
Field.....	90	89	89	89	---
Total.....	143	142	142	142	---

Authorization: Section 103, P.L. 93-438, Section 203, P.L. 95-91.

a/ FY 1985 total does not include $1,650,000 transferred to the SBIR program.
b/ FY 1985 total reflects a reduction of $530,000 for ADP general reduction. Totals reflect a reduction of $2,455,000 in FY 1985, $2,735,000 in FY 1986, and $3,074,000 in FY 1987 for management initiative savings.
c/ FY 1986 total reduced by $7,071,000 in accordance with P.L. 99-177, the Balanced Budget and Emergency Deficit Control Act of 1985 (Gramm/Rudman/Hollings).

Department of Energy

FY 1987 Congressional Budget Request

Adjustments to FY 1986 Appropriations

	FY 1986 Confer. (1)	General Reduction (2)	Management Initiatives (3)	Pay Cost Restoration (4)	FTE General Reduction (5)	Gramm-Rudman-Hollings (6)	ESAH Transfer/ Reprogramming (7)	Subtotal (8)	Comparability Adjustments (9)	Total (10)
Environmental R&D										
Biological & Environmental Research										
Operating Expenses Biological and Environmental Research	$174,700	$ -1,000	$ -935		$ —	$ -6,988		$166,217		$166,217
Program Direction	3,600	-251	—		-93	-127		3,129		3,129
Subtotal	178,300	-1,251	-935		-93	-6,835		169,346		169,346
Capital Equipment	7,750					-293		7,457		7,457
Construction	3,250					-123		3,127		3,127
Subtotal, Biological and Environmental Research.....	189,300	-1,251	-935		-93	-7,071		179,950		179,950
General Reduction:										
Operating Expenses	-1,251	1,251								
Capital Equipment										
Construction										
Total, General Reductions	-1,251	1,251								
Management Initiatives:										
Operating Expenses	-935		935							
Capital Equipment										
Construction										
Total, Management Initiatives	-935		935							
Total, Biological & Environmental Research.....	187,114				-93	-7,071		179,950		179,950
Operating Expenses	176,114				-93	-6,835		169,366		169,366
Capital Equipment	7,750					-293		7,457		7,457
Construction	3,250					-123		3,127		3,127

DEPARTMENT OF ENERGY
1987 CONGRESSIONAL BUDGET REQUEST
SUMMARY OF CHANGES
BIOLOGICAL AND ENVIRONMENTAL RESEARCH
(In thousands of dollars)

1986 Appropriation enacted	$ 187,021
1986 Gramm-Rudman reduction	- 7,071
1986 adjusted	179,950
o Continue analytical characterization in support of complex chemical studies; enhance occupational health research; maintain development of advanced radiation and chemical instrumentation	+ 1,761
o Sustain field and laboratory studies on transport and transformation of radionuclides, organics and trace elements through atmospheric, terrestrial and aquatic media	+ 3,010
o Maintain epidemiologic studies; expand automated health effects detection system; continue studies of biological markers, and long-term experimental radiation and complex chemical mixtures research.	+ 8,237
o Expand molecular biology research, especially gene library work; accelerate structural biology efforts re pulsed neutron sources; continue cell biology and chemical physics research	+ 1,917
o Sustain carbon dioxide research program of data collection, measurement and modeling; implement a few high priority research recommendations from state-of-the-art report	+ 994
o Curtail development of new nuclear medicine procedures through production and labeling of new radionuclides, instrumentation advancement, and demonstration of clinical feasibility and extend techniques to elucidate the basis for mental disease and normal brain and heart functions	- 1,191
o Increase program direction for increased personnel costs	+ 471
o Emphasize support for capital equipment and construction needs	+ 1,416
FY 1987 budget request	$ 196,565

	FY 1985	FY 1986	FY 1987 Request
Biological and environmental research.....	$187,746	$179,950	$196,565
1. Late Effects on Health and Environment of Energy Development and Use			
a. Source and Dose Determination.....	15,656	14,810	16,571
b. Environmental Processes and Effects.....	32,383	29,867	32,877
c. Health Effects.....	63,424	57,710	65,947
d. General Life Sciences.....	28,535	27,953	29,870
2. Nuclear Medicine.....	21,335	23,311	22,120
3. Carbon Dioxide Research.....	13,072	12,586	13,580
4. Program Direction.....e.....	3,475	3,129	3,600
5. Facility Operations.....	9,866	10,584	12,000
	$187,746	$179,950	$196,565

1. Late Effects on Health and Environment of Energy Development and Use

This component of the BER program carries out the Department's responsibility for conducting a comprehensive program of research and development on the human and environmental health effects of energy technologies and programs. The research is managed in four closely interrelated areas in order to fully encompass this complex program responsibility. The first subprogram, Source and Dose Determination, provides physical and chemical information on energy-related materials released to the environment, and develops advanced techniques for measuring exposure to these agents. The next subprogram, Environmental Processes and Effects, improves our capability for describing the transport and transformation of materials through the atmospheric, marine, and terrestrial environment and evaluates their effects on ecosystems. The Health Effects subprogram investigates the human health consequences of exposure by direct studies on human populations that have been exposed occupationally, accidentally or for medical purposes, and by research at the molecular, cellular, and experimental animal level. Underlying this targeted effects research effort is a fundamental research subprogram, General Life Sciences, which explores the mechanisms whereby physical and chemical agents interact with biological systems to produce damage and how such damage is either repaired by normal biological processes or expressed as observable end effects such as cell death, mutation or cancer.

a. Source and Dose Determination.....	15,656	14,810	16,571

Evaluation of the exposure of a human or ecological population to radiation or chemicals is the initial step in estimating consequent health effects. The exposure may be determined indirectly by characterizing a radiation or chemical source and tracking the agents from source to receptor population, or directly by measuring the exposure with suitable instruments. The source and dose determination program develops the necessary information and techniques to address this responsibility. Analytical Studies are pursued to define the chemical and physical nature of energy-related agents that may be sources of human or ecological exposure. Such agents may be direct sources of exposure in the workplace, or they may be released to the general environment with consequent general population exposure. Dosimetry Research is designed to improve methods for the direct determination of human exposure to energy-related agents. Research in Measurement Science develops the advanced radiation and analytical instrumentation required to pursue effectively the broad scope of the health and environmental effects research program.

Analytical Studies

The enhanced exposure of the general population to **environmental radon** in residential and commercial buildings due to the application of advanced energy conservation technology may result in health risks to the general public that considerably exceed those from any other energy technology. An expanded effort is planned to develop predictive models which describe indoor levels of radon and radon daughters as a function of soil concentration, porosity and permeability, of building design, and of ventilation practice. This research on the sources and transport mechanisms of radon, the properties of radon decay products in the indoor atmosphere, and the factors affecting the ultimate energy deposition in the respiratory system will be applied to health effects studies and the development of appropriate mitigation and control techniques.

Chemical characterization programs are currently defining the biologically active ingredients in complex chemical mixtures related to energy production and use. A continued orderly reduction in this effort is planned in concert with the restructuring of the chemical mixtures research program which is directed at establishing principles for predicting the health effects of such mixtures in humans.

Dosimetry Research

Accurate measurement of dose not only enables a reliable determination of individual exposure, but also provides data needed to improve work practices and to reduce worker exposure. Current dosimetry research includes radiation dosimeter development with emphasis on mixed field neutron-gamma exposures, internal and external dosimetry technology, and on techniques for assessing exposure to energy-related chemicals. A new research initiative to develop and evaluate dosimetry techniques for assessing indoor exposure to thoron (radon-220) and thoron daughter products will be pursued. In addition, enhanced studies on particle growth and size distribution on attachment rates for radon and thoron daughters and on their fate in the indoor environment will be conducted.

The important Japanese **A-bomb survivor dose reassessment** will continue at a lower level, emphasizing the completion of the overall uncertainty analysis and the final reports for all phases of the program. The dosimetry system in place at the Radiation Effects Research Foundation will be generating the definitive organ dose data needed for the establishment of human dose-response relationships. The results will be applied to the interpretation of radiation monitoring data in terms of relevant radiation protection quantities and for adjustment of protection standards if necessary.

Research is also conducted to achieve improved personnel and field monitoring systems for determination of exposure to organics and other chemical materials related to the nonnuclear energy technologies. Specifically, the use of monoclonal antibodies is currently being investigated as a means of determining exposure to high molecular weight organic hydrocarbons. In addition, the feasibility of measuring and monitoring changes to the DNA molecule as an indication of exposure to organic materials is being explored.

Measurement Science

Progress in chemical characterization, dosimetry research and in a broad range of environmental and biomedical investigations is critically dependent on the availability of **advanced and innovative measurement tools and techniques.** A continuing program of basic and applied research is conducted focusing on key measurement needs. In FY 1987 a phase down of research on instrumentation

techniques for measurement of toxic gases and effluent pollutants will occur as existing projects are completed. New or expanded efforts are planned in semiconductor radiation detection devices, remote measurement techniques for biologically active substances, and laser spectroscopy for chemical analysis.

Basic studies on new techniques for radiation detection now emphasizes advanced semiconductor detectors and specialized electronic signal processing techniques to provide measurement systems with low noise, better sensitivity and high count rate capabilities. Mercuric iodide, in particular, has been shown to operate at ambient temperatures with energy resolution approaching that of today's best liquid nitrogen-cooled silicon detectors. Avoiding the penalties of weight, size, and complexity associated with such cooling makes these mercuric iodide systems particularly attractive for portable and remote applications. A prototype device based on BER-sponsored research at the University of Southern California has, in fact, been flown on space shuttle missions to monitor gamma ray dose to the crew.

Laser-based techniques which enable extremely sensitive and selective measurements are being employed in a variety of applications. Resonance ionization spectroscopy, particularly in combination with mass spectroscopy, continues to find important new uses. Measurement of as few as 1000 atoms of the isotope Kr-81 in groundwater has been successfully demonstrated thereby providing a means of dating samples several million years old. This information can be used to model the subsurface transport of toxic substances and to help identify potential waste disposal sites. A laser-excited solid state fluorescence technique called fluorescence line narrowing spectroscopy (FLNS) has been applied to measurement of the compounds ("adducts") formed between DNA and carcinogenic polycyclic aromatic hydrocarbons. These adducts are believed to be an early step in the development of cancer and may ultimately provide a foundation for more precise assessment of risks. The FLNS technique is so powerful that it can detect a single adduct in one hundred million DNA bases, and can distinguish between adducts formed by different carcinogens.

Research to improve the detection and measurement of hazardous chemicals has produced a technique for distinguishing very similar hydrocarbons by negative-ion mass spectrometry. This technique is based upon the differing electron affinities of otherwise similar compounds, i.e. their ability to capture an electron. It is now possible to distinguish biologically active compounds such as benzo(a) pyrene, a potent carcinogin, from its inactive isomer, benzo(e) pyrene, thus improving the capability for quantifying the hazardous component of complex mixtures.

	FY 1985	FY 1986	FY 1987 Request
b. Environmental Processes and Effects.....	$ 32,383	$ 29,867	$ 32,877

In FY 1987, an increase is planned for atmospheric and environmental research. Funds will be used in the marine program for development of automated instrumentation to measure water chemistry and particle abundance, thereby reducing future requirements of expensive ship time. In the terrestrial area, research on radon exhalation from soils and building material will be enhanced to develop predictive models for determining radon flux under different environmental conditions and thereby allow better prediction and mitigation of indoor radon. Also, controlled field scale experiments will be initiated to provide much needed information on the use of natural systems as detoxification and mitigation filters for energy contaminants in soil and ground water.

Upon release of agents from an energy source, it becomes necessary to understand their transport and transformation through atmospheric, terrestrial and marine media in order to estimate the subsequent exposure to humans and the environment. This research activity dates from the early weapons testing era when information on the transport and fate of fallout radionuclides was needed. To meet this need, a comprehensive program in the physical and ecological sciences was established which today is being applied to multiple energy-related activities.

Another component of the environmental research program centers on the response of ecosystems, populations and individual species affected by energy-related disturbances and discharges. This effort aims at the anticipation of environmental impacts before they happen, and at the understanding of these impacts in order to allow the prevention or alteration of deleterious consequences.

Atmospheric Transport and Transformation

The BER program in the atmospheric sciences is concerned with the movement of energy-related pollutants through the atmosphere (transport) and their chemical and physical changes during transport until they are deposited on the earth (transformation). The FY 1987 request will sustain ongoing research programs with some additional emphasis on atmospheric organic chemistry.

A question central to the acid rain issue is the relationship between emissions in the midwest and acidic deposition in the northeast. The **"PRECP program"** (Processing of Emissions by Clouds and Precipitation) was initiated in FY 1985 to investigate the proportionality between pollutant releases, particularly SO_2 and NO_x, and the subsequent deposition of acidic species at great distances.

The PRECP program became fully operational in FY 1985. Field experiments were designed to determine the aqueous phase changes that sulfur and nitrogen compounds undergo as they are incorporated into various cloud systems. This design attempts to provide measurements of sulfur, nitrogen and other reactants in the air mass entering the cloud, in-cloud chemical changes, and analysis of the products leaving the cloud. A series of field experiments, centered in Columbus, Ohio, was carried out during April 1985. An "air cavalry" methodology was employed with various aircraft being deployed over a wide area to capitalize as much as possible on promising meteorological situations. The results of these studies and of laboratory-chemistry studies and modeling efforts will provide significant input to the major on-going National Acid Precipitation Assessment Program (NAPAP) effort to develop a comprehensive Regional Atmospheric Dispersion Model. The program in FY 1987 will emphasize analysis and interpretation of the massive data cumulated in the field experiments, and will plan field experiments in different types of storm systems.

The FY 1985 **ASCOT** (Atmospheric Studies in Complex Terrain) **experiments** in Colorado addressed valley flows and the coupling of the local flows with regional scale winds. The experiments involved a massive collection of meteorological and chemical tracer data. These data will form the basis for FY 1987 field experiments in Western Colorado. The decision has been made to extend the range of the ASCOT experiments from 10's of kilometers to 100's of kilometers and to continue to study the exchange of air masses between adjacent valley systems.

A new initiative begun in FY 1986 was the **Western Air Chemistry study.** Initially, this involved an effort to document the air chemistry of the ASCOT area and other relatively unpolluted Western regions. In FY 1987, this program will address the air chemistry of energy related emissions and their interaction with organic emissions from vegetation in the very sunny and arid atmosphere of

the West. It is anticipated that this work will be closely coordinated with other chemistry research related to the reactions of organic emissions with ambient pollutants such as SO_x, NO_x and ozone.

The data from the FY 1984 Cross Appalachian Tracer Experiment (CAPTEX) forms the basis for a model comparison workshop scheduled in early FY 1986. The CAPTEX data base made possible the first comprehensive comparison of long range dispersion models and as such has made a major contribution to the understanding of regional scale tropospheric transport and dispersion. Plans are being developed for additional tracer experiments on the multi-thousand kilometer scale.

The applied laboratory and field programs in atmospheric science will continue to be undergirded by a continuing fundamental research effort to provide kinetic and thermodynamic data measurements for important atmospheric chemical reactions.

Marine Transport and Transformation

Beginning with the study of processes that distributed radioactive fallout through the oceans into the food chain, this program has pioneered the use of natural and artificial radionuclides to determine movement and mixing rates of water masses, flushing rates and major sinks of contaminants in the coastal zone and deeper oceanic areas. In the future, the ocean will have to be seriously considered for disposal of some of the waste products generated by expansion of energy technologies. Research conducted under this program on cycling and movement of materials off our coast will provide crucial information for decisions on appropriateness for ocean disposal of these wastes.

The present program is subdivided into three regional areas. In the Northeast a 10 year research program has been planned to analyze processes that move and alter materials, from the atmosphere and surface water to the continental shelf. Called SEEP (Shelf-Edge Exchange Processes), this program examines the mechanisms that remove chemicals from the water, and the processes that cause contaminants to bind to the sediments or to be released back to the water column. The first phase of SEEP has been completed and has caused considerable excitement among oceanographic scientists because the movement of particles offshore to the continental shelf appears to be along trajectories not originally expected. The second phase (SEEP II) will be initiated in 1987.

In the Southeast, our marine research has discovered how Gulf Stream eddies and upwelling drive water masses and nutrients on the mid and outer shelf. These studies on Gulf Stream intrusions have been synthesized into a recent comprehensive publication on outer-shelf dynamics. Present research is being concentrated on the near-shore zone where a front of freshwater from coastal rivers exists. The SPREX (Spring Experiment) of 1986 and FLEX (Fall Experiment) in 1987 will help determine why cross shelf transport is so spasmodic in this region, and what controls the periodicity and volume of the discharge to the deeper off-shelf ocean waters. Early evidence indicates that most near-shore currents move along shore but that periodically, the trapped coastal water appears to escape seaward particularly in the spring and in the fall seasons. This research contributes to a better understanding of the removal of chemicals, wastes and other materials from the near shore region and their transport across the continental shelf.

In the deep ocean basins off California, a new program will investigate the vertical and horizontal movement of materials. This study will address the interaction of waste runoff materials with particles in the water and their decomposition and remineralization.

Terrestrial Transport

Research in this area has focused historically on the transport and accumulation of radionuclides and other energy materials through environmental pathways leading to humans and the migration of these materials in soil and water especially around DOE facilities. This research has demonstrated which plants and animals concentrate radionuclides and other chemicals, and which chemical, physical, and biological properties can minimize their uptake in ecosystems.

A challenge for the next decade will be to better understand the biogeochemical mechanisms that affect the toxicity of chemical contaminants, and the movement of these materials in subsurface environments. Specifically, information is required on the hydrological transport of organic compounds, trace metals, and radionuclides; geochemical attenuation by soils and geological strata; and uptake of contaminants by biological systems in order to understand the boundaries within which terrestrial disposal of waste is possible and environmentally acceptable. Not only costly, engineered solutions but also natural systems can provide an important link to effective disposal and detoxification. This program concentrates on natural systems as mitigation factors. Advanced technologies including supercomputers, fiber optics, and remote sensing are an integral part of this research. Beginning back in FY 1983, increased priority was given to energy-related organic contaminants, their decomposition products and movement of these constituents in the ground water. This emphasis will continue to expand through 1987.

National Laboratory-University consortia have been formulated to focus scientific resources on this important research area. In the period FY 1987 - FY 1990, controlled field scale experiments will continue to provide an essential intermediate step for larger controlled experiments at natural sites beyond FY 1990.

Ecosystem Functioning and Response

Energy production and development can affect water use and produce varying degrees of landscape disturbance. Prediction of the extent and persistence of such human-related impacts is critically important, as is the development of mitigation strategies for reducing serious impacts. Prediction and mitigation can be successful only if basic processes affecting ecosystem functioning are well understood.

Past research conducted under this program has elucidated the sulfur cycle in forested ecosystems which is now providing crucial information on acid rain. Information on carbon cycling developed with support of this program is now a central part of the evaluation of CO_2 buildup.

In FY 1986, this program focuses on the understanding of changes in ecosystems functions in relation to water stress. For example, at the DOE National Environmental Research Park at Savannah River, the existence of different radioisotopes in surface and ground waters and sediments, and comprehensive background information on hydrology and ecological systems provide a unique opportunity to conduct research on wetland processes at several levels of ecosystem organization.

This emphasis on water stress is also being applied to arid and semiarid ecosystems at the Nevada Test Site and the National Environmental Research Parks at Idaho Falls, Hanford, and Los Alamos, and in the extreme cold regions of the Arctic tundra. Models integrating across complex organizational levels from individual cells to ecosystems are being actively developed along with manipulative studies at these diverse sites. Thus, in addition to research at the

watershed and landscape unit level, this program explores the physiological responses of organisms to water stresses which affect the composition and health of the communities. This hierarchical approach to ecosystem modeling has put this program in the forefront of ecological theory especially as concerns the application of quantification methodologies for the spatial patterning of landscapes.

Such research is also important for providing the basic foundation for utilization of biotechnology techniques in the environment. The better the knowledge of how systems work, the better is our ability to predict optimal usage of biotechnology within the environment.

	FY 1985	FY 1986	FY 1987 Request
Health Effects.....	$ 63,424	$ 57,710	$ 66,947

The Health Effects research program provides a continuing source of information required to ensure that the operations and policies of the Department can be supported in terms of protecting the health of workers and the general public. Research in this program is designed to meet that responsibility by the development of a broad, scientifically sound data base for evaluating the potentially adverse health effects that could result from exposures to radiation and chemical agents most relevant to Department of Energy programs and operations. There are two principal subprograms. One program utilizes human epidemiological data obtained from selected human populations known to have been exposed acutely to moderately high, or to chronically low levels of external radiation, internally deposited radioactive materials, or complex chemical materials of the type that could be encountered, for example, in connection with the production or use of synthetic fuels. The other subprogram is designed to provide detailed health effects data, including data on mechanisms by which health effects are induced and expressed, which cannot be obtained from human studies. This subprogram makes use of experimental animals chosen on the basis that they are useful models for human beings. In addition, animal organ and tissue cultures, as well as animal and human cell cultures, are extensively used (1) to develop an understanding of basic mechanistic principles involved in the production of radiation and chemical effects which are applicable to most species and (2) to strengthen our capability to extrapolate experimentally-derived data to man. Both subprograms include molecular-level studies. Like other parts of the overall OER program, the Health Effects research program depends on basic biological research to provide new methods and concepts which quickly find application in both subprogram areas.

Human Health Effects

The epidemiologic research program comprises studies which attempt to provide needed scientific data and, at the same time, provide information of important practical significance. These studies include investigations of human populations with occupational or environmental exposure to energy-related pollutants. Among the major populations which have been under study for several years are DOE/DOE contractor workers, Japanese atomic-bomb survivors, nuclear shipyard workers, and New Mexico uranium miners. These population studies will be supplemented by studies of lung cancer cases in Pennsylvania and New York and of communities located near DOE facilities. The former studies are attempting to determine if there is a potentially causal relationship between lung cancer and residential exposure to radon gas and its progeny. The latter study utilizes previously-collected data such as the 1960, 1970 and 1980 censuses and mortality

data compiled by the National Center for Health Statistics, to investigate clustering of diseases related to proximity to DOE laboratories and other operations.

During FY 1987, the results of the nuclear shipyard study will be available. These results have been anxiously awaited for some time, and are expected to greatly refine our confidence in low-level radiation risk estimates which have been developed through extrapolation from populations exposed at high doses and dose rates. Also during FY 1987, it is expected that expansion of the Health Surveillance System now operating at two DOE sites will begin to provide unique data on morbidity effects from occupational exposures at DOE facilities. Similarly, the intensive effort to characterize the industrial hygiene aspects of these facilities in order to identify chemical hazards which may be responsible for some apparently deleterious health effects that have been discovered in previous epidemiologic investigations will continue.

Biological markers research looks for those subtle changes from the normal in biological function or morphology that are associated with exposure to a pollutant of concern. Once identified, these biological markers may then be applied in epidemiology, clinical research and occupational medicine or, conversely, these fields may provide the association which ultimately identifies the marker. Ongoing efforts include a project that is correlating consistent chromosome aberrations with radiation and/or chemical exposures. This project has been expanded to identify the oncogenes involved in these aberrations, possibly leukemia genes. Another biological markers project is obtaining, by direct inspection, information on the chromosome constitution of normal human spermatozoa as well as those from men who may have been exposed to potentially harmful pollutants. This research will provide for the first time a method to analyze large numbers of human germ cells. In another study, specific locus mutations are measured directly in human sperm. It will be the first method of this kind. These interrelated efforts at the forefront of human molecular biology will continue at a slightly increased level. A new project to study cultured human cells for cytotoxic and genetic damage after exposure to indoor complex mixtures will begin in 1987.

DOE policy has long encouraged conservation techniques in both residences and workplaces. Nationwide, new building technology has gone far in implementing these policies -- at the same time, public power utilities have actively encouraged weatherization of existing structures. Assuring human health and safety in these tightened structures, a result of DOE conservation policy, is an objective of indoor air quality research. Efforts studying the health effects of advanced conservation techniques will continue, and further work on indoor complex chemical mixtures as well as biological aerosols in energy saving, heating and cooling systems will begin. While radon has been the most serious concern and focus of much of the human health research, these other areas remain largely unexplored by any Federal agency. Wherever possible, such research will be done in a cooperative fashion with other agencies such as the Consumer Products Safety Commission, Environmental Protection Agency, and Health and Human Services to assure maximum use of existing facilities and available funds.

An expanded radon research program will initiate several new innovative human exposure methods such as radon bioassay development. Pb-210 (Lead) in mine and mill workers has shown promise as an indicator of the integrated radon daughter exposure. A two-part study to measure Pb-210 concentrations in former mine and mill workers, while they are still alive, and preserved animal bones and bones obtained at autopsy from uranium workers will further investigate the utility of this integrator of radon daughter exposure. In addition, recent highly sensitive laser analysis techniques have been developed for obtaining data on human exposure

to uranium. Radon and daughters in blood or urine are two possible indicators of current (perhaps integrated) exposure to radon and radon daughters. These biological dosimeters offer the potential of measurement of population as well as worker exposures and will be developed in conjunction with the animal experiments.

Experimental Health Effects Research - Biological Systems

The principal source of health-risk information upon which existing standards and guidelines for limiting human exposure to biologically active environmental agents are based on the analysis of increased incidences of cancer and other late-occurring diseases in human populations exposed to those or similar chemical or physical agents. It has become increasingly obvious that human data alone are inadequate to provide such information for some of the radiations and energy-related complex chemical mixtures of specific concern to the Department of Energy. Similarly, inadequate data are available for predicting human health effects resulting from exposures to combinations of toxic organic compounds and radiation, a situation that must be considered in many occupational and public exposure situations.

To meet these needs, the experimental health effects research program aims at providing health risk evaluation data from carefully controlled laboratory-based studies using a multispecies comparative approach encompassing multiple levels of biological complexity (animals, organs/tissues, cells, and molecules). This approach seeks predictive correlations between cellular/molecular events and whole animal responses. The program has two major thrusts; (1) to supply the kinds of quantitative experimental data that can be used as a primary source of information to assess human risk, and (2) to provide, on a continuing and progressive basis, a scientifically sound data base to remove or minimize the uncertainties that exist in developing useful human risk assessments. Two distinct but interrelated subprograms exist for meeting these goals within the restricted mission of the Department. To meet the first objective, detailed toxicological dose-response studies are conducted with long- and short-lived laboratory animals to provide reliable quantitative estimates of increased incidences of delayed somatic effects that result from low-level exposure to ionizing radiations or complex chemical mixtures related to energy production and use. Similar studies are also conducted to provide detailed experimental evaluation of the genetic risk for heritable mutations that could result from exposure to the same physical and chemical agents. Most of these studies attempt to duplicate the chronic, low-dose exposure conditions that might be expected to exist for occupational groups, as well as the general population, as a result of the activities of the Department. At the same time, however, basic research studies are carried out to evaluate the importance of exposure and biological variables, including dose-rate and age at time of exposure, in modifying risks of delayed somatic and genetic effects. This second objective is met by a subprogram which seeks to provide an understanding of the basic physical, chemical, and biological mechanisms involved in production of delayed somatic and genetic effects in mammalian cells, tissues, organ, and organisms. These latter studies are not only inherently important in establishing general biological principles in toxicology but also in establishing a sound basis for extrapolating experimentally-derived data to estimation of human health risks.

Late Effects Dose-Response Studies

The largest segment of this program involves the use of long-lived animals to provide lifetime risk data for induction of cancer and life-shortening by internally deposited alpha-emitting radionuclides of importance in production of fissionable material and by actinide radioisotopes as well as gamma- and beta-emitting fission products that are of concern in nuclear waste management

activities of the Department. Some of these studies were initiated 7-12 years ago and the data obtained constitute a primary source of health risk information for use on a continuing basis. These programs will be adequately supported to their completion. The animal populations involved in the radionuclide studies are presently nearing the post exposure age when they will become at high risk for developing cancer. Materials taken from tumors and normal tissues of these animals provide an invaluable resource to study the relationships between molecular markers, such as oncogenes and chromosome alterations in radiation induced cancer. Such studies were initiated at Pacific Northwest Laboratory in FY 1985 and if successful, will be expanded in FY 1986 and FY 1987. On a multilaboratory basis, studies define the microdosimetry of deposited radionuclides and the specific target cells for cancer induction.

Increased effort will be made to better define human health risks associated with nonoccupational exposures to radioactive radon daughter products. Animal inhalation studies will focus on quantitative radon exposure - response relationships for tumor induction by radon daughters in the rodent respiratory tract. This work will be coordinated with efforts to identify unequivocally cells at risk of tumor development and to measure the absorbed radiation dose (i.e., deposition of energy) in critical cellular targets. Basic cell research will be used in conjunction with flow cytometry in work on the separation and characterization of target cells. Molecular correlates of cellular responses to radon daughters will also be evaluated, including expression of cell oncogenes. Additional animal studies will be conducted to clarify the role and importance of cigarette smoke as a factor in modifying risks from inhaled radon daughters. This research will define tumor initiating and promoting activities of radon daughters and cigarette smoke and determine if the sequence of exposure to these toxic materials may significantly affect the final biological response. Information gained from the total multilevel research effort, as planned, should improve the interpretation of human health studies and better define radon-daughter dose levels that are of concern in regard to the general population.

The major emphasis in the **external radiation studies** is devoted to better quantifications of the maximum RBE (relative biological effectiveness) of neutrons at low doses and low dose-rates. It is obvious now that detailed animal dose-response studies are not logistically or economically feasible for the dose range below 10 rad. New types of statistical models are being used to make the best use of existing data approaching that dose range. Such analysis now suggest that there is a linear dose-response relationship for both neutrons and gamma rays, which argues for a constant RBE in that crucial dose-range. A number of short-term in vitro cell studies have been initiated to test the hypothesis of constant RBE at doses in the range of 1 rad of neutrons. There is some indication to date that x- and gamma radiation actually are "incomplete carcinogens" in that secondary factors, not directly related to the radiation itself, may determine whether or not tumors develop. These studies, when coupled with the in vivo/in vitro cell and tissue studies described below, may resolve many of the existing questions that have been raised in the health protection community about the need to reduce the maximum permissible dose of neutrons for workers in the DOE program. These critically important studies will be accelerated in FY 1987.

Dose-response studies in short-lived animals (rodents) will continue in order to define classes of chemicals in energy-related complex chemical mixtures that produce late somatic effects other than cancer (e.g., congenital abnormalities, neurotoxicity, immunotoxicity). Additional dose-response studies in rodent species will be needed to validate carcinogenic and mutagenic properties previously observed in cell bioassay studies. Also, in need of validation in the mammalian organism are synergistic and antagonistic interactions that are known to occur between components of complex mixtures when examined in simple model

systems. The principal goal of research in this area is to develop sufficient understanding of factors controlling the properties of complex mixtures so that toxicologic properties may be estimated from readily measured chemical and biological parameters. Hence, basic and mechanistic research is emphasized, as discussed below. In research on both radiation and chemical mutagenesis, improved methods for detecting, monitoring, and quantifying heritable mutations in human and animal populations is urgently needed and will be expanded. Current research in the General Life Sciences area is developing molecular techniques for characterizing molecular alterations in both genes and gene products (e.g. protein molecules). As these methods become available for routine use, they will be applied in genetic studies of exposed animals.

Mechanisms of Production of Late Effects

As was mentioned earlier, there are limited human data available for making sound estimates of human health risks associated with low-level exposure to the kinds of radiations or complex chemical mixtures of concern to the Department. This subprogram aims to reduce the uncertainties in using that limited information as well as the larger data base derived from laboratory-based experiments to obtain such estimates. The research provides a fundamental understanding of the physical and chemical reactions that can produce biological damage and the molecular and cellular changes that lead to the observed genetic and somatic effects in important target organs and tissues of mammalian species. When such studies are conducted on a comparative basis, they provide a sound basis for extrapolation of experimentally derived data to human beings.

Ongoing research in radiological physics will be supported on a continuing basis to supply the data needed for a quantitative understanding of the early physical events (energy deposition and transfer) which lead to important biological damage. Recent emphasis has shifted from studies of gas phase reactions to the more biologically relevant reactions in condensed systems. Also, special emphasis will continue to be given to understanding the reactions with high-LET radiations including neutrons.

In the same vein, **biological studies** will continue to provide detailed understanding of the kinds of changes in key macromolecules (notably DNA) that can result in genetic changes including those that are likely to be involved in cancer production. Special emphasis will continue to be placed on research which compares those molecular changes that result from exposure to ionizing radiations and to toxic chemicals since evidence is now accumulating which suggests that it will be possible to differentiate between the kinds of mutations and molecular damage that are produced by chemicals, ionizing radiation, and ultraviolet radiations. Such information could be extremely important for developing molecular markers that can be used to estimate mammalian exposure to chemical mixtures or radiations.

Special emphasis will be given to studies that relate **cellular/ molecular changes** in the intact animal to given exposures of ionizing radiations or complex chemical mixtures. Several "multilevel" model systems have been developed which allow direct intercomparison of cells of a given tissue in the intact animal with cells cultured *in vitro*. For example, cells in the tracheal epithelium, mammary gland, and thyroid gland of rodent species can be exposed to ionizing radiations or chemical agents either inside or outside of the animal and their subsequent growth and differentiation followed either *in vivo* (i.e., in animal body) or outside of the animal (*in vitro*). Similarly, cells exposed previously to chemical mixtures or radiations in culture can then be implanted into one of the animal models and followed both *in vivo* and *in vitro* to provide detailed information on the molecular changes induced by the exposing agent. This approach is

being exploited in studies of both radiation and energy-related chemicals. Since this type of work meets both of the objectives of this subprogram, funds will be redirected from other parts of the research in order to accelerate these studies, particularly in the case of research on the neutron RBE problem.

Research will also be accelerated to develop a stronger base of knowledge on mechanisms of neutron interactions with biological systems. Although the biological effects of neutron are known to differ significantly from those of x- and gamma radiation, the mechanistic basis of this difference is not known. It is planned to increase effort in research on neutron interactions at the level of the gene. This work will include research on mechanisms of DNA damage and repair. Related studies will explore the possible role of chromosome damage and oncogene activation in neutron carcinogenesis.

In a related area of research, basic studies in cultured cells and intact animals are carried out to elucidate the mechanisms by which components of complex chemical mixtures interact in biological systems to alter toxicologic properties. Nonadditivity of toxicities (synergism, antagonism) appears to be characteristic of highly aromatic organic chemical mixtures from fossil fuels. Such nonadditive effects may be a general property of many types of complex chemical mixtures. Although well demonstrated (e.g., in fossil fuels and cigarette smoke condensate), the cellular/molecular bases for these nonadditive effects are not understood. Increased emphasis will be given to the development of model cellular/molecular systems to elucidate the principles that govern the biological interactions. Attempts will also be made to predict interactions between chemical agents and radiations simultaneously administered to target cells/tissues. Research on specific cellular and molecular markers that correlate with delayed toxicity is also emphasized because of the potential importance of such markers as predictors of toxicologic properties.

Experimental methods have been developed to characterize mutations at the chromosomal and molecular level in a large number of mutant strains of mice developed at the Oak Ridge National Laboratory (ORNL). Emphasis in early FY 1986 will be placed on screening this mammalian mutant collection for those disease phenotypes (from the mutations) that resemble known human disease.

These mutants, carried in stock at ORNL, constitute a unique research resource for studies in mammalian heritable mutagenesis. Besides being an important component of heritable mutagenesis studies of interest to this Department, the various mutant strains of mice are made available on request to other investigators, in and outside DOE, who are interested in pursuing such work.

This subprogram is fortified by the strong General Life Sciences program described below.

	FY 1985	FY 1986	FY 1987 Request
d. General Life Sciences.....	$ 28,535	$ 27,953	$ 29,870

Research in General Life Sciences contributes to the base of fundamental biological knowledge that is required for the effective study and interpretation of energy-related health effects. It also identifies early indicators of biological damage, develops new techniques and experimental systems for research use, and provides knowledge that eventually becomes used in the estimation of human health risk. Research in this category also supports the development of new instruments to analyze biological systems and the use of special facilities at the National Laboratories, such as neutron sources for the determination of

biological structure, and state-of-the-art capabilities in scanning transmission electron microscopy, that are heavily used by the academic community for research and training.

Research on normal cell processes and functions and their regulation will be strongly supported and will emphasize studies to understand how cells divide and differentiate and what factors influence or regulate them. A related problem is to understand which cellular factors influence the stability of the differentiated state and which ones may be involved in the transformation of normal cells to a malignant state. This research is related to ongoing studies of proteins on the surfaces of cells that act as part of a membrane transport system or are part of cell receptor sites which transmit hormone-borne signals from the outside to the inside of cells. Rapid advances are being made in our understanding of the manner in which a variety of hormones or chemical regulators interact with receptor sites (regulatory sites) on cell surfaces in ways that serve to control cell growth and function. Results from recent research indicate that the presence of abnormal chemical regulators in the cell environment may trigger aberrant growth leading to tumor formation. This important concept, including the possibility that abnormal chemical regulators with tumorigenic properties may be products of activated proto-oncogenes, will be vigorously investigated. Specialized cells of the immune system such as macrophages and lymphocytes are also being studied to help us understand how the immune system acts to protect the mammalian organism from the consequences of cellular damage brought about by energy-related pollutants.

Research in genetics will focus on the structure and function of the gene, its normal and mutated configurations at the molecular and chromosomal levels, and how genes with modified structures are expressed and regulated. Of particular importance are studies aimed at identifying and cloning human genes involved in repairing specific types of radiation damage. Emphasis is shifting in other research at both the animal and cellular levels toward explaining the physicochemical and molecular basis of mutations induced by various kinds of radiations and chemical agents. Of continuing interest is r search on the different spectra of mutations and DNA base-sequence changes that are produced in certain animal and human cells by chemicals and radiations. Induced mutations and structural changes appear to differ from those arising spontaneously. Preliminary evidence suggests that different mutagens may differ in the spectra of structural alterations they produce in DNA molecules. Another critical area of genetics research addresses the mechanisms underlying differentiation, neoplasia, and aging. Included is research designed to elucidate the manner in which cellular "oncogenes" may be activated or amplified by carcinogenic agents. Molecular characterization of normal and mutant genes in both somatic and germinal cells of rodents, longer-lived animal species, and humans using recombinant DNA techniques and other bioengineering approaches will be emphasized.

Research in chemical physics is investigating the fundamental processes that govern the distribution of energy within biological molecules. These studies are being made in large organic and biological molecules so that the data can be applied directly toward understanding the biological effects produced by exposure to ionizing radiation or to energy-related chemical mixtures.

Important progress is being made in biophysical research and instrumentation directed toward the development and application of advanced systems for measuring and determining the structure of complex components of living cells. Instruments of interest include electron microscopes, flow cytometers, and advanced optical devices. For structural biology studies at the National Synchrotron Light Source (NSLS), a beam line for the vacuum ultraviolet ring has been equipped with instrumentation to study the structure of nucleic acids and proteins. A very

fast, position-sensitive x-ray detector has been developed for rapid, dynamic studies of molecular structures using the x-ray ring. With these developments, studies of the structure of biological molecules have begun at both the UV and x-ray rings of the NSLS.

Recent structural studies have identified a new form of RNA, named Z-RNA, that exists in the form of a left-handed double helix in which the two component strands of the helix wind around one another in a counter-clockwise fashion. Future research will seek to determine the biological significance, if any, of Z-RNA. Another important study has produced a detailed characterization of structural alterations induced in the DNA molecule by ultraviolet radiation (UV) and by interaction with the chemical compound, psoralen, to form a crosslink between adjacent DNA strands. Both types of agents were found to produce a kink in the normally linear DNA double helix accompanied by partial unwinding of the helical structure at sites of damage. The availability of well characterized samples of damaged DNA is expected to facilitate new research on molecular mechanisms of mutagenesis.

Improvements in the resolution, machine stability, and sorting speed of flow cytometers have made it possible to sort chromosomes with better than 95 percent purity for gene mapping and studies of chromosome damage, and to provide DNA samples for the construction of chromosome specific recombinant DNA libraries.

Research on a prototype electronic camera system for detection of radioisotope-labeled biological molecules separated on 2-dimensional gels or chromatograms was completed. Compared to conventional autoradiography with films, the time required for analysis of 2-dimensional gel separations was reduced by a factor of 10-100 along with improved linearity and dynamic range. An improved version of the camera, now under development, should allow direct quantitative counting of most radioisotopes with a spatial resolution of 0.5 mm and will be used in genetics research.

	FY 1985	FY 1986	FY 1987 Request
2. Nuclear Medicine Applications.....	$ 21,335	$ 23,311	$ 22,120

The use of radiation and radionuclides in the study, diagnosis and treatment of human disease is the foundation of the field of Nuclear Medicine. Historically, DOE and its predecessor organizations have played a vital role in the development of this field. This development has been possible largely because of access to the unique facilities and skills in the laboratories supported by the Department of Energy. These facilities include nuclear reactors, particle accelerators and nuclear instrumentation. Moreover, the skills of nuclear physicists and nuclear chemists have been essential factors in transferring nuclear technologies to medical applications.

The objective of the FY 1987 research program is to continue the development of new nuclear medicine procedures through the production of new radionuclides, the radiolabeling of new biologically active agents, and advancements in instrumentation. Efforts to develop other medical applications using reactors, accelerators and other related nuclear technologies will be maintained.

Within the Federal government this mission and DOE's facilities for conducting research in this area are unique. Liaison is maintained with Federal agencies (principally NIH and FDA), the radiopharmaceutical industry, and the medical community regarding the requirements and effective use of these techniques in medical research and practice.

Research emphasis on radionuclide production in this time period will be on the development of generator systems for short-lived radionuclides. Such generator systems consist of a parent nuclide, having a half-life ranging from hours to days, which decays to a daughter having a half-life ranging from seconds to minutes. The daughter can be periodically removed from the generator for clinical use. At present, most short-lived radionuclides are produced by a cyclotron which severely limits their availability. These generator systems will permit nuclear medicine procedures to be performed in medical facilities which do not have a cyclotron on the premises. A potential new initiative in FY 1987 is the development of a cerium 134/lanthanum 134 generator which appears to be attractive for bone marrow studies. Preliminary studies with lanthanum-140 as a tracer showed a high bone marrow uptake for lanthanum compounds. The advantages of short-lived radionuclides are lower radiation dose to the patient and the ability to conduct real time function studies.

In addition, significantly advanced isotope production capability is required. Most present accelerators were not designed for the production of medical isotopes. What is needed are dedicated cyclotrons that utilize advanced technologies such as superconducting magnets or adaptatéons of linear accelerators for exclusive isotope production. Improved targetry incorporating high efficiency radiochemical procedures which are remotely controlled would greatly contribute to advancing this research area. Finally, computer controlled, fully automated radiopharmaceutical preparation and delivery systems are required for broad application in a clinical situation.

Recent developments in the BER nuclear medicine program have produced new radiopharmaceuticals labeled with short-lived radionuclides. In syntheses involving the most important positron emitting radionuclides (Oxygen-15, 2 minutes; Nitrogen-13, 10 minutes, Carbon-11, 20 minutes and Fluorine-18, 110 minutes), one cannot use standard techniques. Rather, innovative rapid organo- and biosynthetic techniques must be developed using the technologies of molecular biology, biochemistry, organic chemistry, hot atom chemistry and radiochemistry.

The new short-lived radionuclide labeled radiopharmaceuticals are proving to be useful in studies of the metabolic functions of the brain and heart. However, the major advances that have been made to date in quantitating physiology and pathophysiology in the human brain and heart cannot be consolidated or advanced without proceeding to the next generation of biomedical studies utilizing Positron Emission Tomography. There is an urgent need for whole-body PET's to conduct research toward improving our understanding of cardiovascular physiology in man and of metabolism and mechanical function. In addition, successful development of advanced tomographic systems will have immediate medical implications in evaluation of stroke patients and diagnosis of degenerative brain disorders such as Alzheimer's, Huntington's and Parkinson's disease.

In FY 1987, research and development will be maintained and devoted to identifying and optimizing techniques for attaching radionuclides to monoclonal antibodies. Monoclonal antibodies have the potential for early detection of cancer, for following the response of patients to treatment, and for general cancer therapy. A substantial research and development effort will be required to perfect and evaluate techniques for using labeled monoclonal antibodies. It is anticipated that by FY 1987 work on monoclonal antibodies for cancer therapy labeled with yttrium-90, fermium-255, and einsteinium-253 will have progressed to the point that one or more of these agents will have been identified as having sufficient potential for clinical trials. In addition, the monoclonal antibody work will be extended to labeling with radionuclides suitable for positron tomographic diagnostic imaging.

Instrumentation research conducted by interdisciplinary teams at the DOE laboratories provides a conduit for transferring advanced electronic and detector technologies developed at the DOE facilities to the medical community. A major emphasis at present is on the development of a next-generation positron emission tomograph (PET). Presently available commercial PET systems have a resolution in the range of 8-12 mm, with two experimental systems reaching a resolution in the 5-6 mm range. These PET systems are capable of providing an image of changes of metabolic activity, but lack sufficient resolution to give quantitative measure of the specific activity in small subregions of an organ. Progress in this field has been rapid and it is anticipated that development of a prototype PET system with spatial resolution in the 2-3 mm range is likely in FY 1987.

The use of magnetic resonance imaging (MRI) spectroscopy to detect carbon-13 and nitrogen-15 labeled metabolites within intact tissues and cells holds exceptional promise in providing new insight into the mechanisms responsible for metabolic regulation. Because of the great importance of heart disease, current research efforts are focused on the identification of the metabolic effects in the perfused heart model of several proposed therapeutic strategies for treatment of ischemic heart disease. Efforts will be concentrated on obtaining quantitative measurements of metabolic concentrations in the heart. Most of the current applications of NMR to studies of metabolism have avoided the issue of determining the concentrations of metabolites under observation by emphasizing relative changes in the signal intensities of the metabolites detected. It is clear that much more information could be obtained from the spectra by quantitation.

A cooperative project between Brookhaven National Laboratory and Stanford University utilizing synchrotron radiation to reduce the hazards of angiography will be continued.

	FY 1985	FY 1986	FY 1987 Request
3. Carbon Dioxide Research.....	$ 13,072	$ 12,586	$ 13,580

The FY 1987 budget request for the Carbon Dioxide Research program is $13,580,000. This budget provides for: a few of the highest priority recommendations from the State-of-the-Art publications to be implemented; a very basic program of data collection and continuation of measurements and development of models; possibly one new crop (rice) will be added to the study of vegetation response to elevated atmospheric CO_2 levels; minimal monitoring of research activities of other trace gases (e.g., methane) may be possible; monitoring, but no direct participation in the International Geosphere Biosphere Program (IGBP); and, finally, a minimal core ocean program needed to couple the atmosphere, oceans and the biosphere.

The goal of the Carbon Dioxide Research program is to develop a sound, quantitative atmospheric carbon dioxide knowledge base to aid in energy policy decision making. This goal involves the following objectives: improve knowledge of the carbon cycle; improve estimates of future atmospheric carbon dioxide; improve understanding of the effects of atmospheric carbon dioxide on climate; improve understanding of the direct carbon dioxide effects on productivity of natural and agricultural systems; develop and verify methods for the first detection of climate change due to increasing atmospheric carbon dioxide; identify, define and quantify indirect effects; define possible options for mitigating long-term consequences of a higher CO_2 atmosphere.

Carbon dioxide is a small but important component of the earth's atmosphere. The global CO_2 content of the atmosphere has increased from about 315 parts per million (ppm) to 345 over the past 26 years and is presently increasing by about 1.5 ppm annually. The majority of the CO_2 increase is a direct result of man's fossil energy use.

Increasing amounts of CO_2 and other trace gases in the atmosphere could enhance the "greenhouse effect", which would result in warming of the lower atmosphere. This, in turn, could cause changes in patterns of precipitation, evaporation and wind circulation. In the last decade, physically-based, mathematical simulation models of the global atmosphere have tended to give added credence to these projections. More CO_2 will modify plant growth with the potential for increased crop productivity and changed composition of natural vegetation.

The effects of continuing CO_2 increases in the atmosphere are uncertain. The magnitude and rate of man's future use of fossil fuel further complicate the already uncertain picture. However, the scientific consensus is that global climate change involving temperature and precipitation will occur. The timing, magnitude, regionality and any subsequent benefits and/or costs are uncertain, and the extent of the uncertainty is not yet defined.

	FY 1985	FY 1986	FY 1987 Request
4. Program Direction			
Operating Expenses	$ 3,475	$ 3,129	$ 3,600
Total FTEfs	53	53	53

The FY 1987 request for Biological and Environmental Research Program Direction is $3,600,000. These funds are required to provide for the personnel and other costs associated with continuation of 53 full-time equivalents.

This staff directs, manages, and supports a comprehensive multidisciplinary research effort designed to understand the long-term health and environmental effects associated with the development and use of fossil, nuclear and renewable energy technology options as well as the Department's nuclear weapons operations. In carrying out these responsibilities, the staff provides guidance and support for approximately 760 active research projects (reviewing and evaluating many more throughout the proposal selection process), develops long-range program plans based on their assessment of the scientific needs of the program and agency priorities, and conducts major reviews of BER sponsored programs at laboratories and universities. This requires a close liaison with other DOE programs, other Federal agencies and the scientific, academic and industrial communities. This staff also provides the administrative and program support services required to carry out the program.

The BER program has been reoriented toward a greater commitment to basic research requiring a wide range of scientific and technical expertise in all of the subprograms. This program direction request will provide the staffing resources to maintain the various professional scientific disciplines necessary to evaluate efforts carried out in the multiprogram laboratories, specialized biomedical and environmental facilities and over 125 universities, hospitals and other research institutions. The wide range of required expertise includes disciplines such as biochemistry, biophysics, molecular and cellular biology, genetics, toxicology, radiation biology, epidemiology, nuclear medicine, physiology, analytical chemistry, atmospheric sciences, ecology, oceanography and many others. There are also demands on staff for increased outreach efforts for Departmental

commitments to Small Business Innovative Research and Historically Black Colleges, and for support of the Health and Environmental Research Advisory Committee (HERAC).

	FY 1985	FY 1986	FY 1987 Request
5. Facility Operations.....	$ 9,866	$ 10,584	$ 12,000

Facility operations provide for the necessary capital equipment and general plant project needs to support the BER program and the Pacific Northwest Laboratory landlord responsibilities. The national laboratories and other onsite specialized laboratories supported by the BER program represent an impressive national resource of skilled investigators, advanced major scientific instrumentation and exceptionale often unique, reseaech facilities. The ability to address the diversity of health and environmental research issues requires a continued commitment to maintaining their advanced instrumentation and facilities. Capital equipment ($8,500,000) and general plant projects ($3,500,000) are essential elements to facility operations.

Recent years of constrained budgets have resulted in a serious backlog of state-of-the-art equipment needs. Also, existing equipment at the laboratories is suffering from deterioration and obsolescence and is in urgent need of replacement. The capital equipment request for this program is essential for pursuing the health and environmental issues associated with energy technology considerations and to continue high quality research and advances in the development of nuclear medicine technology. Examples of capital equipment needed at laboratories and universities to support research include: scanning electron microscope, liquid chromatograph, liquid scintillation counter, spectrometer, amino acid analyzer, environmental chamber, infrared analyzer, animal caging, etc. Many of these items are interchangeable among various research efforts, and therefore, can serve numerous experiments over a period of time, making them very cost effective.

The capital equipment request also supports general purpose equipment needs at the Pacific Northwest Laboratory (PNL). General purpose equipment requirements at PNL fall into two broad capital support categories: (1) providing PNL support services and tools of a nonprogrammatic nature such as Safeguards, Safety, Security, etc; (2) PNL provides various support services such as Environmental Surveillance, Personnel Dosimetry, Photography, etc. for the entire Hanford complex.

Construction funds of $3,500,000 are requested in support of the program's general plant project needs and the Pacific Northwest Laboratory landlord responsibility. General plant projects are necessary to accommodate continuing requirements to maintain satisfactory and economical operating conditions, to meet regulatory requirements and to provide for new program developments. Process development and changes in technical program requirements frequently result in the need for alterations or new construction items not previously anticipated. In addition to satisfying programmatic requirements, general plant projects provide the alterations and additions to existing facilities needed to: 1) satisfy radiation protection, health and safety, environmental protection, and energy conservation requirements; 2) improve operating efficiency; and 3) provide optimum utilization of existing facilities.

DEPARTMENT OF ENERGY
1987 CONGRESSIONAL BUDGET REQUEST
CONSTRUCTION PROJECT DATA SHEETS
ENERGY SUPPLY RESEARCH AND DEVELOPMENT
ENVIRONMENTAL R & D
BIOLOGICAL AND ENVIRONMENTAL RESEARCH
(Tabular dollars in thousands. Narrative material in whole dollars.)

1. Title and location of project: General plant projects

2. Project No.: 87-R-120

3. Date A-E work initiated: 1st Qtr. FY 1987

3a. Date physical construction starts: 2nd Qtr. FY 1987

4. Date construction ends: 2nd Qtr. FY 1989

5. Previous cost estimate: None
Date:

6. Current cost estimate: $3,500
Date: 12/85

7. Financial Schedule:

Fiscal Year	Obligations	Costs FY 1985	Costs FY 1986	Costs FY 1987	Costs After FY 1987
Prior Year Projects	XXXXXXXX	$ 4,034	$ 1,848	$ 726	$ 205
FY 1985 Projects	$ 2,725	256	365	1,099	1,005
FY 1986 Projects	3,127	0	364	1,300	1,463
FY 1987 Projects	3,500	0	0	875	2,625

8. Brief Physical Description of Project

This estimate is for minor new construction and other capital alterations to land, buildings, and utilities systems. The estimate also includes the cost of installed equipment which is an integral part of the general plant subprojects.

1. Title and location of project: General plant projects

2. Project No.: 87-R-120

8. Brief Physical Description of Project (continued)

Although it is difficult to detail this type project in advance, all of the subprojects identified below are under consideration. In general, the estimated costs for each of the subprojects are preliminary in nature, with a project limitation of $1,200,000, and primarily indicative of the size of the project. The continuing review of our requirements will result in some of the projects being changed in scope; it will also result in other projects being added to the list with the necessary postponements of some now listed, all depending on conditions or situations not apparent at this time. Since needs and priorities may change, other projects may be substituted for the examples listed below, and some of these may be located on non-Government owned property. These general plant projects will provide facilities for conducting critical research programs, contribute to greater efficiency, eliminate health and safety hazards, and will reduce maintenance and operational costs.

The estimate is based on requirements by office as follows:

Summary by Office	
Albuquerque Operations Office	$ 1,500
Oak Ridge Operations Office	500
Richland Operations Office	1,000
San Francisco Operations Office	500
Total	$ 3,500

9. Purpose, Justification of Need for, and Scope of Project

The following is a tentative tabulation of the major projects to be performed at the various laboratories under the operations office listed.

Albuquerque Operations Office

Inhalation Toxicology Research Institute ..... $ 1,000
Controlled material storage facility, primate housing facility modifications, chilled water system, and other emergency repairs.

Los Alamos National Laboratory 500
Health research laboratory addition and other emergency repairs.

1. Title and location of project: General plant projects — 2. Project No.: 87-R-120

9. Purpose, Justification of Need for, and Scope of Project (continued)

Oak Ridge Operations Office	
Oak Ridge Associated Universities	500
Low humidity chromatography room, replacement of roof at Scarboro facility, and other emergency repairs.	
Richland Operations Office	
Pacific Northwest Laboratory	1,000
Miscellaneous capital work orders, e.g., laboratory additions, improvements, and modifications.	
San Francisco Operations Office	
Lawrence Livermore National Laboratory	500
Upgrade air handling and toxic exposure animal facility, refurbish water circulation system for marine biology, and other emergency repairs.	

10. Details of Cost Estimate

Based on preliminary conceptual design.

11. Method of Performance

Design will be by negotiated architect-engineer contracts. To the extent feasible, construction and procurement will be accomplished by fixed-price contracts awarded on the basis of competitive bids.