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The eight multiprogram laboratories under the Department of Energy (DOE) are Government-owned research and production facilities operated by university, industry, or nonprofit contractors. In the past, most of their resources have been directed toward nuclear energy, but they have more recently developed capabilities in the fields of nonnuclear energy research, development, and demonstration (RD&D).

Findings/Conclusions: The nonnuclear energy tasks undertaken by the laboratories have been relatively small and often appear to focus on fragmented portions of technologies. The initial organizational alignment of the laboratories, with five under an Assistant Secretary or Office responsible for specific programs, is not conducive to their role in nonnuclear energy RD&D.

Factors tending to restrict the laboratories' involvement in this area include: the piecemeal basis by which their roles were determined, DOE's emphasis on using private industry, incompatibility with the Administration's emphasis on near- and mid-term technologies, DOE's reluctance to expand the laboratories, and competition from other in-house research facilities. Also, the laboratories' roles in nonnuclear RD&D have not been adequately defined. In defining the roles, relationships with other research entities should be considered and issues addressed involving the extent of missions in this area, management responsibilities, use of laboratories to funnel money to other institutions, and policy planning.

Recommendations: The Secretary of Energy should: align the laboratories to a separate Office which is not responsible for specific programmatic areas; closely monitor the development of the planning, programming, and budgeting system to ensure timely

implementation, giving priority to defining the roles of the laboratories and integration with DOE's energy R&D efforts; assess ramifications of assigning missions in each of the technologies being developed; assign missions, including support roles, in areas where other entities have greater capabilities; augment staff capabilities; delegate authority to carry out management responsibilities; and expand the laboratories' advisory roles within assigned missions. (HTW)

BY THE COMPTROLLER GENERAL

Report To The Congress

OF THE UNITED STATES

The Multiprogram Laboratories: A National Resource For Nonnuclear Energy Research, Development, And Demonstration

During recent hearings, the Congress expressed concern over how the enormous scientific and technical potential of the Department of Energy's eight multiprogram laboratories is being harnessed toward the development of nonnuclear energy technologies.

The eight laboratories represent a cumulative capital investment of over \$3 billion. They have a diversity of scientific and technical resources, manpower, and plant facilities for developing new energy technologies.

However, their roles in nonnuclear energy research, development, and demonstration have not been defined adequately by the Department and they have had little working relationships with other research activities carrying out such efforts.

This report examines several issues regarding the roles of the multiprogram laboratories and presents suggestions for using these laboratories in nonnuclear energy in a manner which would improve their working relationships with other research entities.





COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

B-186105

To the President of the Senate and the
Speaker of the House of Representatives

This report discusses the nonnuclear energy research, development, and demonstration roles and capabilities of the Department of Energy's multiprogram laboratories.

During recent hearings, the Congress expressed concern over how the enormous scientific and technical potential of these laboratories is being harnessed toward the development of nonnuclear energy technologies. Our report examines this issue and presents an approach for using these laboratories, while also involving the private sector.

We made our review pursuant to the Budget and Accounting Act of 1921 (31 U.S.C. 53), and the Accounting and Auditing Act of 1950 (31 U.S.C. 67).

We are sending copies of this report to the Director, Office of Management and Budget; the Secretary of Energy; interested congressional committees; and other interested parties.

A handwritten signature in black ink, reading "James E. Beardsley".

Comptroller General
of the United States

COMPTROLLER GENERAL'S
REPORT TO THE CONGRESS

THE MULTIPROGRAM LABORATORIES:
A NATIONAL RESOURCE FOR NON-
NUCLEAR ENERGY RESEARCH, DEVEL-
OPMENT, AND DEMONSTRATION

D I G E S T

The eight multiprogram laboratories have a diversity in scientific and technical resources, manpower, and plant facilities, which in the past has been directed toward nuclear energy and nuclear weapons efforts. Because our Nation's oil and gas supplies are dwindling these laboratories are diversifying toward developing more efficient methods of using our existing fuel supplies and alternative sources of energy. (See p. 2.)

This report examines the roles and capabilities of the eight multiprogram laboratories

- Argonne National Laboratory, Darien, Illinois.
- Brookhaven National Laboratory, Upton, New York.
- Lawrence Berkeley Laboratory, Berkeley, California.
- Lawrence Livermore Laboratory, Livermore, California.
- Los Alamos Scientific Laboratory, Los Alamos, New Mexico.
- Oak Ridge National Laboratory, Oak Ridge, Tennessee.
- Pacific Northwest Laboratory, Richland, Washington.
- Sandia Laboratories, Albuquerque, New Mexico and Livermore, California. (See pp. 2-3.)

These laboratories have developed a variety of mutually supportive capabilities in

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performing fundamental research and nuclear weapons and nuclear energy research, development, and demonstration (RD&D). GAO examined a number of nonnuclear energy tasks undertaken by the laboratories and found that they have applied and built upon these capabilities. (See p. 4.)

However, the nonnuclear energy tasks undertaken by the eight laboratories have been relatively small and often appear to focus on fragmented portions of technologies. (See p. 28.)

The Department of Energy's initial organizational alinement of the multiprogram laboratories is not helpful to their use in nonnuclear energy RD&D programs. In organizing the multiprogram laboratories, the Department alined

--three to the Assistant Secretary for Defense Programs;

--two to the Director, Office of Energy Research; and

--three to the Under Secretary.

GAO believes the alinement of five multiprogram laboratories to an Assistant Secretary or Office responsible for specific programs will, if continued, tend to erode their capabilities in other areas, such as nonnuclear energy RD&D. (See p. 57.)

The roles of these laboratories in nonnuclear energy RD&D have not been adequately defined. The former Energy Research and Development Administration had criteria for delineating their roles in the various phases of energy RD&D, but these criteria were informal and too generalized to adequately define the laboratories' roles in nonnuclear energy RD&D. (See p. 37.)

That agency also had proposed a system for integrating its program planning, budgeting, and review processes, with participation by the multiprogram laboratories, and had issued the requirement for implementation on July 20, 1977. Such implementation was

scheduled to occur during the fiscal year 1979 budget process. However, this system has been replaced by a new one. The Department of Energy will adopt some pieces of the earlier system, but these pieces are not yet fully integrated into the new system. (See p. 40.)

Factors tending to restrict the involvement of the laboratories in nonnuclear energy RD&D include:

- the piecemeal basis by which roles of the multiprogram laboratories were determined;
- the Department's emphasis on using private industry for developing nonnuclear technologies;
- the incompatibility of the laboratories' perceived roles with the Administration's increased emphasis on the near- and mid-term energy technologies;
- the Department's reluctance to expand the laboratories; and
- competition from other in-house research facilities. (See pp. 44-45.)

These factors suggest that the laboratories' nonnuclear energy RD&D roles need to be defined in a manner that would improve the relationships among all research entities involved in nonnuclear energy RD&D, including universities and industry.

In this matter, five principal issues need to be considered:

- Should the laboratories have significant missions in nonnuclear energy RD&D?
- How extensive should the laboratories' roles be in basic research, technology development, engineering development, and demonstration?
- Should the laboratories have the authority to carry out project management responsibilities?

--Should the laboratories be used for funneling money to universities and industry?

--How extensively should the laboratories be involved in setting policy, plans, and priorities? (See pp. 59-61.)

KEY CONCLUSIONS

These laboratories should be aligned to a separate office, such as the Office of the Under Secretary, which does not have responsibility for specific programs. (See p. 74.)

The Department of Energy may encounter delays in developing and carrying out its planning, programming, and budgeting system unless sufficient management emphasis is directed toward its expeditious implementation. In implementing the system, the Department should particularly emphasize those aspects of the system intended to define the roles of multiprogram laboratories in nonnuclear energy RD&D. (See p. 75.)

The Department needs to analyze the ramifications of assigning missions to its multiprogram laboratories including the impact of such assignments on work being carried out by universities and industry. (See p. 76.)

Based on such analyses and its programmatic priorities, the Department then should determine the roles of each laboratory within an overall framework whereby the laboratories have sufficient roles in nonnuclear energy areas. Appropriate roles should include mission assignments so that the laboratories are used as effectively as possible and the Department has the needed in-house capability for effective program management. (See p. 76.)

The laboratories' infrastructures for carrying out assigned missions should be augmented by expertise in the various social and political sciences to make certain the socioeconomic, political, institutional, environmental, and legal implications are adequately considered during the development of the energy

technologies. Such a holistic approach to energy RD&D is needed so that all ramifications of energy technologies are adequately considered and well understood prior to making major commitments to their development. (See p. 76.)

With respect to their roles within assigned missions, the laboratories should have increased responsibilities. However, for some projects, particularly demonstration projects, to facilitate technology transfer and ultimately commercialization it may be more appropriate to delegate such responsibilities directly to industrial contractors. For other projects in the early phases of a technology's development or those that industry cannot or does not want to do, it may be impractical to delegate such responsibilities to industry. In such cases, project management functions should be delegated to the laboratories and they should subcontract appropriate tasks to industry and universities. (See pp. 76-77.)

The laboratories also should have an expanded advisory role within their respective missions. Former control over programs was diluted because of insufficient staffing and expertise and certain management support functions were contracted to industry. Headquarters program managers should obtain more needed advice and technical assistance from the laboratories and concentrate on performing the essential management functions needed to maintain control of their programs. (See p. 77.)

RECOMMENDATIONS

GAO recommends that the Secretary of Energy:

- Align the eight multiprogram laboratories to a separate office, such as the Office of the Under Secretary, which is not responsible for specific programmatic areas.
- Closely monitor the development and implementation of the planning, programming, and budgeting system to ensure its timely implementation, giving particular attention and highest priority to those aspects

which are intended to define the role of the multiprogram laboratories and integrate such roles into the Department's energy RD&D efforts.

- On the basis of each laboratory's capabilities, make an in-depth assessment of the ramifications of assigning missions to the multiprogram laboratories in each of the nonnuclear energy technologies being developed.
- Based on such an assessment, assign to the multiprogram laboratories missions where appropriate, including specific support roles in areas where other research entities have greater capabilities.
- Consistent with such mission assignments, augment staff capabilities at the laboratories, and within the Department, to include sufficient expertise in the various social, economic, and political sciences to make certain that all aspects of energy technologies are adequately considered in a holistic approach to their development.
- Delegate to the laboratories authority to carry out day-to-day management responsibilities for projects within their assigned missions that are not appropriate for industry. In these cases, closely monitor each laboratory's use of project funds to ensure that appropriate work segments are subcontracted to the private sector and other entities.
- Expand the multiprogram laboratories' advisory role within their respective assigned missions. (See pp. 77-78.)

DEPARTMENT OF ENERGY
COMMENTS

The Department of Energy objected to the recommendation to align the eight multiprogram laboratories to a separate office which is not responsible for specific program areas and said it was "not clear" that augmentation of staff capabilities, consistent with the various missions, to include expertise in the

social, economic, and political sciences, was needed. The Department generally agreed with the basic thrust of GAO's other recommendations and pointed out that steps are already being taken to carry them out.

GAO made revisions in the report to take the Department's concerns into account, but reaffirms that actions along lines recommended are needed. (See pp. 79-81.)

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ABBREVIATIONS

AEC	Atomic Energy Commission
DOJ	Department of Defense
DOE	Department of Energy
ERDA	Energy Research and Development Administration
GAO	General Accounting Office
NASA	National Aeronautics and Space Administration
NSF	National Science Foundation
NSF/RANN	National Science Foundation/Research Applied to National Needs
OTA	Office of Technology Assessment
PPBR	Program Planning, Budgeting, and Review System
R&D	Research and development
RD&D	Research, development, and demonstration
SERI	Solar Energy Research Institute

DEFINITIONS OF KEY TERMS

- Mission** - A common purpose, objective, or goal usually focused toward meeting a national need. Agency missions involve the programs, functions or subfunctions which, by law, the agency and its component organizations are required to carry out (for example, to develop the energy technologies necessary to make this Nation self-sufficient in energy). As applied to a laboratory, missions involve the projects or tasks to be undertaken by that laboratory (for example, nuclear weapon design and testing).
- Program** - A series of related projects which continue over a period of time--normally years--which are directed toward achieving part or all of a mission.
- Project** - A series of related tasks aimed at accomplishing all or a portion of a program's objectives.
- Tasks** - A specific undertaking with a specified goal and time schedule.

CHAPTER 1

INTRODUCTION

To help solve the Nation's energy problems new technologies must be developed to increase the efficiency of energy use, expand the use of more abundant fuels, and make the transition to new fuels. The potentially catastrophic effects of energy shortfalls to the Nation's defense, its economy, and the health and safety of its people make it imperative that national resources with potential for developing new energy technologies in both supply and conservation are optimally used.

Upon beginning operations on October 1, 1977, the Department of Energy (DOE) inherited research and production facilities from the former Energy Research and Development Administration (ERDA) including 8 multiprogram laboratories, 32 specialized laboratories, and 16 nuclear materials and weapons production facilities. All of these research and production facilities are Government-owned, but most of them are operated by university, industry, or nonprofit contractors. These facilities represent DOE's principal technical arm, a capital investment of nearly \$15 billion, and employ over 105,000 people. (See table 1.)

Table 1
DOE Research and
Production Facilities

<u>Type of facility</u>	<u>Number of facilities</u>		<u>Cumulative capital investment (note a)</u> (millions)	<u>Staffing as of 9/30/77</u>
	<u>Government operated</u>	<u>Contractor operated</u>		
Multiprogram laboratories	-	8	\$ 3,115	40,657
Specialized laboratories	7	25	2,928	21,424
Nuclear materials and weapons production facilities	-	<u>16</u>	<u>8,764</u>	<u>43,522</u>
Total	<u>7</u>	<u>49</u>	<u>\$14,807</u>	<u>105,603</u>

a/Capital investment authorized through fiscal year 1977.

The 8 multiprogram laboratories and 13 of the specialized laboratories are involved in energy technology research, development, and demonstration (RD&D). Each of the multiprogram laboratories have multidisciplinary capabilities and carry out work in basic research and a variety of weapons and energy RD&D programs. These 13 specialized laboratories are principally involved in specific fossil or nuclear energy areas. For example, five of the specialized laboratories are Government-owned and -operated energy research centers which carry out work in specific fossil energy areas such as oil shale, gas, coal, and petroleum. These energy research centers are small in comparison to the multiprogram laboratories and in total represent a capital investment of about \$58 million and employ about 800 people.

DOE also inherited responsibility for setting up the Solar Energy Research Institute (SERI) which began operations in July 1977 at Golden, Colorado. The facility is being set up for DOE by the Midwest Research Institute--a nonprofit research organization--which is the managing/operating contractor for SERI. Funds for the first year of operation are estimated to be \$4 to \$6 million. SERI's primary mission is to foster widespread use of all aspects of solar technologies. Its staff consisted of about 80 professionals in September 1977 and is expected to grow to 374 by 1980. SERI's roles are to include program resource assessments, information gathering and dissemination, and research activities in specific aspects of DOE's solar energy program.

The other 18 specialized laboratories and the 16 production facilities are involved in specific areas of physical research; weapons research and development (R&D), testing, and fabrication; biomedical and environmental research; or nuclear materials production.

We focused on the multiprogram laboratories because they represent large national resources for carrying out RD&D and there has been considerable congressional and executive branch interest in the energy-related roles of these resources. The recent creation of DOE (Public Law 95-91, August 4, 1977) presents an opportune time to examine how these resources are being used to develop new energy technologies. Although these laboratories have traditionally been involved in nuclear energy and nuclear weapons efforts, our Nation's dwindling oil and gas supplies have necessitated that these facilities diversify their efforts toward developing more efficient methods of using our existing fuel supplies and developing alternative energy sources.

This report examines the multiprogram laboratories' roles and capabilities and major issues surrounding their energy RD&D

roles. It also proposes an approach for determining their roles. These laboratories and their principal locations are

- Argonne National Laboratory, Darien, Illinois;
- Brookhaven National Laboratory, Upton, New York;
- Lawrence Berkeley Laboratory, Berkeley, California;
- Lawrence Livermore Laboratory, Livermore, California;
- Los Alamos Scientific Laboratory, Los Alamos, New Mexico;
- Oak Ridge National Laboratory, Oak Ridge, Tennessee;
- Pacific Northwest Laboratory, Richland, Washington; and
- Sandia Laboratories, Albuquerque, New Mexico and Livermore, California.

CHAPTER 2

THE MULTIPROGRAM LABORATORIES--

A PERSPECTIVE ON THEIR ROLES

AND CAPABILITIES

The eight multiprogram laboratories were established in the 1940s and 1950s for the development of nuclear weapons and fundamental nuclear energy research requiring large-scale facilities. Consequently, the laboratories' efforts have been historically concentrated in three areas--fundamental nuclear science, nuclear energy, and nuclear weapons. The Congress expanded the laboratories' roles to include environmental and safety research in 1967 (81 Stat. 577) and nuclear energy RD&D in 1971 (85 Stat. 304). Although the laboratories have expanded their efforts to these latter two areas, their principal efforts have remained in their nuclear-related roles.

In examining nonnuclear energy tasks undertaken by the laboratories, we found that they have applied and built upon their multidisciplinary capabilities developed in their fundamental research and nuclear weapons and nuclear energy RD&D efforts. Hence, it appears to us that the laboratories' technical capabilities can be applied to the development of nonnuclear energy technologies and that a clear delineation of their roles in such areas is needed. However, the nonnuclear energy tasks undertaken by the multiprogram laboratories have been relatively small and often appear to focus on fragmented portions of technologies. In addition, we noted that the laboratories' capabilities to address socioeconomic issues appear to be limited, and consistent with any expansion of their roles in nonnuclear energy RD&D, their capabilities to address such issues need to be built up.

EVOLUTION OF ROLES

The multiprogram laboratories' roles in the nuclear-related programs were established as the programs historically evolved. The laboratories were established under the former Atomic Energy Commission (AEC). Under AEC, the laboratories and the AEC headquarters program managers established close working relationships in defining programs and the laboratories' missions. Under ERDA, these relationships continued and no major change had been evident in the laboratories' roles in the nuclear-related programs. However, ERDA also had responsibility for developing nonnuclear energy technologies and the laboratories accelerated their diversification to nonnuclear energy RD&D.

Each of the eight multiprogram laboratories was established for nuclear-related R&D work. In beginning operations in 1946, AEC assumed responsibility for the laboratories and facilities involved in the development of the atomic bomb. Seven of the eight multiprogram laboratories were established from these laboratories and facilities.

- The Metallurgical Laboratory of the University of Chicago, which determined the feasibility of a self-sustaining nuclear chain reaction and developed methods for the large-scale production and chemical separation of plutonium for use in nuclear weapons, was established in 1946 as Argonne National Laboratory for basic nuclear energy R&D.
- Oak Ridge National Laboratory was established in 1946 at the site of a plutonium breeder reactor and a chemical separation pilot plant.
- The Berkeley Radiation Laboratory, which researched and developed the uranium isotope separation process, was reorganized as an AEC laboratory in 1946. In 1971 it was split into the Lawrence Berkeley Laboratory for fundamental nuclear research and the Lawrence Livermore Laboratory for nuclear weapons and other applied research.
- Los Alamos Scientific Laboratory was established in 1946 at the site where all nuclear bomb system-related scientific research, development, testing, and fabrication activities were combined. In 1949 the branch of the laboratory responsible for nuclear bomb hardware development, testing, and fabrication became Sandia Laboratories as a result of its expanded ordnance engineering work.
- The Hanford, Washington site of the first full-scale plutonium production and separation plant was established as Hanford Laboratories in 1956. In 1965 the Battelle Memorial Institute assumed operations and changed the name to Pacific Northwest Laboratory. Essentially all RD&D programs underway at that time were nuclear-related with the major effort being the plutonium utilization program which was designed to demonstrate the feasibility of recycling plutonium.

In addition to the multiprogram laboratories that evolved from the development of the atomic bomb, Brookhaven National Laboratory was established in 1947 to develop and operate, for use by universities, large-scale R&D facilities. To ensure effective use of the facilities, a support laboratory was

established with fundamental research groups in high energy physics, accelerator design and construction, nuclear physics, solid state physics, nuclear chemistry, and biology and medicine.

AEC's primary mission under the Atomic Energy Act of 1946 (60 Stat. 755) was nuclear energy R&D for national security purposes. However, the act provided that, subject to national security considerations, AEC's nuclear R&D efforts were to be directed also toward improving the public welfare, increasing the standard of living, strengthening free competition in private enterprise, and promoting world peace.

Although national security was the primary concern, the laboratories then in existence began to expand their activities to encompass research associated with peaceful uses of nuclear energy. For example, Argonne, Los Alamos, and Oak Ridge initiated major efforts in nuclear reactor power development and Argonne was assigned lead mission responsibilities for nuclear reactor development in 1948. Under the umbrella of national security, the laboratories, in effect, had a monopoly on nuclear energy R&D.

As the potential for peaceful uses of nuclear energy became more apparent, industry's efforts to fully participate increased. As a result, the Congress enacted the Atomic Energy Act of 1954 (42 U.S.C. 2011 et seq.) which permitted industry to play a major role in developing nuclear power with the help of AEC laboratories. In line with the intent of this act, AEC actively sought greater industry participation in nuclear energy RD&D.

As industries developed the capabilities to translate nuclear science into salable products in the marketplace, AEC increasingly supported their projects. In 1964 nuclear power was considered to have "arrived," and the Congress amended the 1954 act to permit industry to own nuclear materials and facilities. AEC canceled further light water reactor demonstration plants and associated prototype test programs and, instead, supported reactor manufacturers in building businesses on turnkey contracts. Under such contracts a private contractor agrees to complete the work to the point of readiness for operation at which time the reactor is then sold to the customer at a prearranged price. Accordingly, the extent of nuclear energy RD&D work at the laboratories dropped significantly. In 1967, recognizing potential safety and environmental problems, AEC changed its approach from initiating turnkey contracts to building Government-owned facilities to resolve uncertainties, improve and test reactors, and in effect, set standards for all future builders of nuclear reactors. In 1977 three laboratories continued to have major

efforts in nuclear energy RD&D--Argonne and Oak Ridge in nuclear reactors and Pacific Northwest in nuclear fuel cycle development.

In the weapons and basic nuclear sciences work, the laboratories had relative autonomy over the day-to-day management of their RD&D efforts. In the national security program the Department of Defense (DOD), the customer, is responsible for determining the military weapon requirement characteristics, suitability, and acceptability; while DOE, formerly ERDA and AEC, is responsible for weapons development and production. This responsibility in DOE was assigned to the Assistant Secretary for Defense Programs who, in turn, delegated the authority for DOE program execution to the Division of Military Application. The Division of Military Application provides program, but not project, direction for research and development activities at the laboratories. Hence, laboratory directors are given discretionary authority and flexibility as to how they will achieve specific weapons characteristics within a certain level of funding.

Under this framework, the laboratories developed the atomic bomb, the hydrogen bomb, and a family of sophisticated fission and fusion weapons for a variety of uses ranging from large strategic missiles to artillery shells and underwater bombs. Since the roles of the laboratories have evolved into other areas, only three of the multiprogram laboratories are now designated as weapons laboratories--Lawrence Livermore, Los Alamos, and Sandia.

The large fundamental research efforts at laboratories, such as Brookhaven and Lawrence Berkeley, have been basically self-directed by scientists at the laboratories. Although headquarters program staff have been alert to the judgment of eminent scientists and at times confined work to areas relevant to their interests, they have provided little detailed direction over the work carried out by the laboratories in this area.

As a result of their fundamental research efforts, the laboratories have developed particle accelerators; discovered new elements and fundamental particles; developed new materials; expanded the understanding of radiation's effects on people, animals, plants, and materials; discovered radioisotopes for use in industrial, agricultural, biological, and medical research; and advanced medical radiation therapy.

In 1967 the Congress recognized a potential role for the multiprogram laboratories in environmental R&D and expanded the scope of the 1954 act to permit the laboratories to conduct R&D in areas related to public health and safety. As a

result, each of the eight multiprogram laboratories established some level of effort in this area. Although their initial efforts were nuclear-related, their environmental R&D efforts established the foundation for subsequent environmental work in fossil energy and conservation R&D activities in the early 1970s.

Recognizing the need for more efficient methods to meet the Nation's energy needs, the Congress, in 1971, amended the 1954 act to permit the laboratories to conduct nonnuclear energy RD&D for AEC and other agencies. In line with this amendment and because their nuclear-related work and staffing were decreasing, each of the laboratories initiated efforts to use their existing capabilities in nonnuclear energy RD&D. In addition to a limited number of the tasks funded by AEC, the laboratories had tasks funded by the National Science Foundation (NSF) and the Department of the Interior. While these tasks helped develop the laboratories' capabilities in nonnuclear energy RD&D, they were relatively small-scale tasks and amounted to a small part of the laboratories' efforts.

Since the establishment of ERDA in 1975, the Congress has increased emphasis on nonnuclear energy RD&D and the laboratories' efforts in nonnuclear areas have rapidly expanded. In fiscal year 1975 laboratories' total outlays, including those for plant and capital equipment, for nonnuclear energy RD&D were about \$35.6 million, in fiscal year 1976 they increased by about 75 percent to about \$63.3 million, and more than doubled in fiscal year 1977 to \$129.2 million.

Although the laboratories' efforts in nonnuclear energy RD&D increased substantially under ERDA, these efforts represent a relatively small portion of the laboratories' total workload. As shown in table 2, the \$129.2 million of outlays for nonnuclear energy RD&D accounted for only about 8.9 percent of the laboratories' total outlays of nearly \$1.5 billion in fiscal year 1977.

Table 2

Multiprogram Laboratories' Outlays by
Area of Effort for Fiscal Year 1977

<u>Area of effort</u>	<u>Outlays (note a) (millions)</u>	<u>Percent of Total</u>
National security	\$ 636.4	43.7
Nuclear energy	323.0	22.2
Nonnuclear energy	129.2	8.9
Environment and safety (note b)	126.3	8.7
Basic science	226.6	15.5
Program support	5.3	0.4
Work for others (note c)	<u>10.3</u>	<u>0.7</u>
Total	<u>\$1,457.1</u>	<u>100.0</u>

a/Includes outlays for plant and capital equipment.

b/About 31 percent of this effort was associated with nuclear energy, about 27 percent with nonnuclear energy, about 21 percent with more than one energy technology, and about 21 percent with general science and medical applications.

c/Primarily work funded by other Federal agencies.

ACTIVITIES OF THE MULTIPROGRAM
LABORATORIES

The eight multiprogram laboratories carry out work in activities ranging from fundamental research programs in the physical and life sciences to advanced goal-oriented design and development programs in nuclear reactors and nuclear weapons. Each multiprogram laboratory carries out activities in several programs. However, to facilitate our discussion of their activities, we grouped them according to their principal areas of effort as follows:

Weapons laboratories

- Lawrence Livermore Laboratory
Los Alamos Scientific Laboratory
Sandia Laboratories

Nuclear energy and life
sciences laboratories

- Argonne National Laboratory
Oak Ridge National Laboratory
Pacific Northwest Laboratory

Fundamental research
laboratories

- Brookhaven National Laboratory
Lawrence Berkeley Laboratory

Each multiprogram laboratory represents a large Government capital investment and has large professional and support staffs to help carry out their efforts. The large support staffs provide technical and administrative services to the professional staff. Technical support staff often directly participate, along with professionals, on laboratory RD&D tasks and provide such services as drafting, development shop-work, computer support, and equipment and facility maintenance. Administrative support staff provide such services as accounting, budgeting, procurement, personnel, printing, security, legal, and medical.

Weapons laboratories

Each multiprogram laboratory in this group has been assigned the primary mission of developing and testing nuclear weapons and is aligned to the Assistant Secretary for Defense Programs. Lawrence Livermore and Los Alamos are physical science laboratories and are responsible for developing the physics design of nuclear weapons; while Sandia, a systems engineering laboratory, is responsible for developing weapons hardware.

In addition to carrying out their primary nuclear weapons functions, the weapons laboratories carry out many complementary tasks for DOE and other Federal agencies. Examples of support to DOE include work on the laser and magnetic fusion programs, various fission technology alternatives, and use of the laboratories' physical and engineering sciences capabilities to aid in the solar energy, geothermal energy, fossil energy, and conservation programs. The laboratories are also involved in DOE's biomedical, environmental, and basic physical research efforts.

A small portion of the three laboratories' efforts is devoted to non-DOE programs. Activities for DOD agencies include nuclear detection systems, site security systems, earth penetrators, materials science, high-explosive technology, nuclear weapons efforts, and analytical computer modeling. They also carry out small projects for several other Federal agencies, including support to the Nuclear Regulatory Commission on nuclear materials properties, materials safeguards and reactor design and dynamic performance, accident analysis and protection, and health protection.



PHOTO COURTESY OF LOS ALAMOS
SCIENTIFIC LABORATORY

LOS ALAMOS SCIENTIFIC LABORATORY, LOS ALAMOS, NEW MEXICO

These three laboratories subcontract about 40 percent of their funds, primarily for materials, supplies, and construction equipment. Accordingly, each of these laboratories had large procurement staffs ranging from about 100 to 300 people.

Table 3 shows the weapons laboratories' fiscal year 1977 funding outlays, capital investment, and staffing.

Table 3

Weapons Laboratories' Outlays,
Capital Investment, and Staffing
for Fiscal Year 1977

Outlays (millions) (note a)	<u>Lawrence Livermore</u>		<u>Los Alamos</u>		<u>Sandia</u>	
	<u>Amount</u>	<u>Percent of total</u>	<u>Amount</u>	<u>Percent of total</u>	<u>Amount</u>	<u>Percent of total</u>
National security	\$188.8	71.2	\$166.6	61.9	\$273.4	84.4
Nuclear energy	48.7	18.4	54.6	20.3	9.8	3.0
Nonnuclear energy:						
Fossil	6.0	2.3	1.1	0.4	7.6	2.3
Solar	1.1	0.4	1.7	0.6	24.4	7.5
Geothermal	4.3	1.6	6.3	2.3	1.8	0.6
Conservation	2.4	0.9	2.6	1.0	2.2	0.7
Environment and safety	11.1	4.2	9.4	3.5	3.1	1.0
Basic science	1.6	0.6	25.7	9.5	1.5	0.5
Program support	0.8	0.3	0.1	(b)	(c)	(b)
Work for others (note d)	0.3	0.1	1.3	0.5	0.1	(b)
Total	\$265.1	100.0	\$269.4	100.0	\$323.9	100.0
<u>Cumulative capital investment (millions) (note e)</u>	<u>\$390.1</u>		<u>\$651.8</u>		<u>\$461.0</u>	
<u>Staffing (3/31/77)</u>						
Engineering	850	13.0	810	14.3	1,420	27.7
Physical and chemical science	997	15.3	1,079	19.0	399	7.8
Mathematics and computer science	282	4.4	195	3.4	141	2.7
Life and environ- mental science	82	1.3	98	1.7	51	1.0
Social science	23	0.3	-	-	2	(b)
Other professional and support staff	<u>4,278</u>	<u>65.7</u>	<u>3,495</u>	<u>61.6</u>	<u>3,118</u>	<u>60.8</u>
Total	6,512	100.0	5,677	100.0	5,131	100.0

a/Includes operating and capital plant and equipment outlays.

b/Less than .05 percent.

c/Less than \$.05 million.

d/Primarily work funded by other Federal agencies.

e/Capital investments authorized through fiscal year 1977.



PHOTO COURTESY OF LAWRENCE
LIVERMORE LABORATORY. LAWRENCE LIVERMORE LABORATORY, LIVERMORE, CALIFORNIA

Lawrence Livermore Laboratory

Located in Livermore, California, this laboratory is operated by the University of California. Nuclear weapons design accounts for over half of the laboratory's efforts and continues to be its primary mission. It also has activities in laser fusion, magnetic mirror confinement fusion, and laser isotope separation. It has large staffs in theoretical physics, cytogenetics, bioinstrumentation, terrestrial and aquatic ecology, atmospheric modeling, accelerator physics, and chemistry. The laboratory reportedly has the largest research computer complex in the world. Its nonnuclear energy RD&D efforts include in situ gasification of coal, in situ liquefaction of shale, geothermal hot brine, the solar pond method for generating hot water for industrial processes, and resource studies.

Los Alamos Scientific Laboratory

Located in Los Alamos, New Mexico, this laboratory is operated by the University of California. Its major mission is nuclear weapon design and testing, supported by basic and applied research in physics, mathematics, computer applications, chemistry, metallurgy, and materials. It also has efforts in magnetic and laser fusion, medium-energy nuclear physics, molecular biology, biomedical and environmental effects of radiation, waste management, cancer therapy, reactor safety, and nuclear safeguards. Its principal nonnuclear energy RD&D efforts are in geothermal dry rock, solar energy heating and cooling, and superconducting electrical transmission and storage.

Los Alamos operates an 800-million electron volt linear proton accelerator, a weapons neutron research facility, a stable isotope production facility, a high-intensity flash X-ray machine, the Scyllac magnetic fusion facility, a large computer facility, a gas laser facility, and an 8-megawatt nuclear research reactor.

Sandia Laboratories

Located in Albuquerque, New Mexico, and Livermore, California, Sandia is operated by Western Electric Company. It is a research and engineering laboratory principally involved in the development of nuclear weapons. Its major capabilities are in systems engineering and analysis, component development, materials sciences, physical science, testing and instrumentation, engineering analysis, aerosciences, and quality assurance. Sandia's efforts are in nuclear materials, safety and security, electron beam and laser fusion, nuclear reactor safety, nuclear waste management, combustion research, geothermal

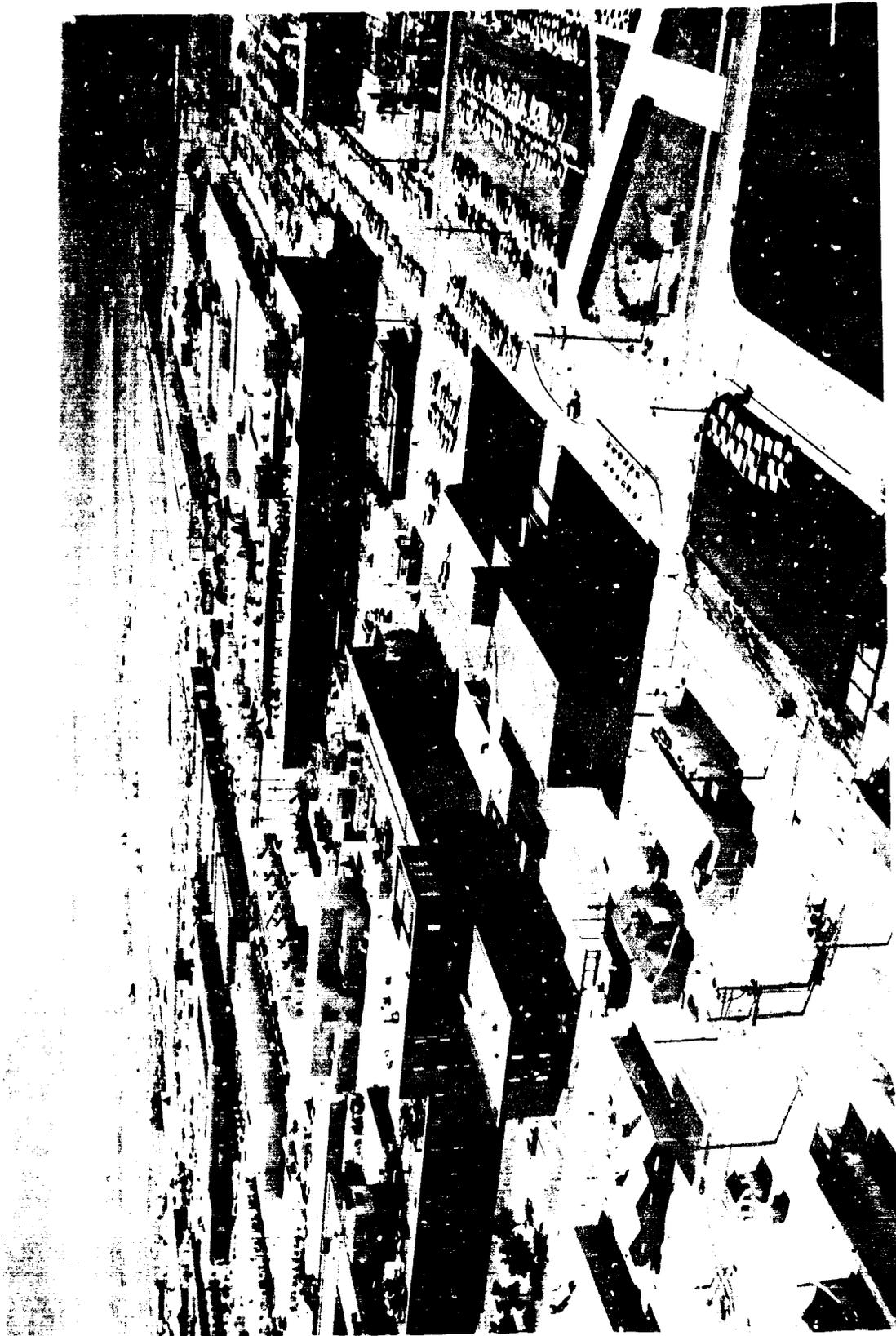


PHOTO COURTESY OF SANDIA LABORATORIES
SANDIA LABORATORIES COMPLEX LOCATED AT ALBUQUERQUE, NEW MEXICO

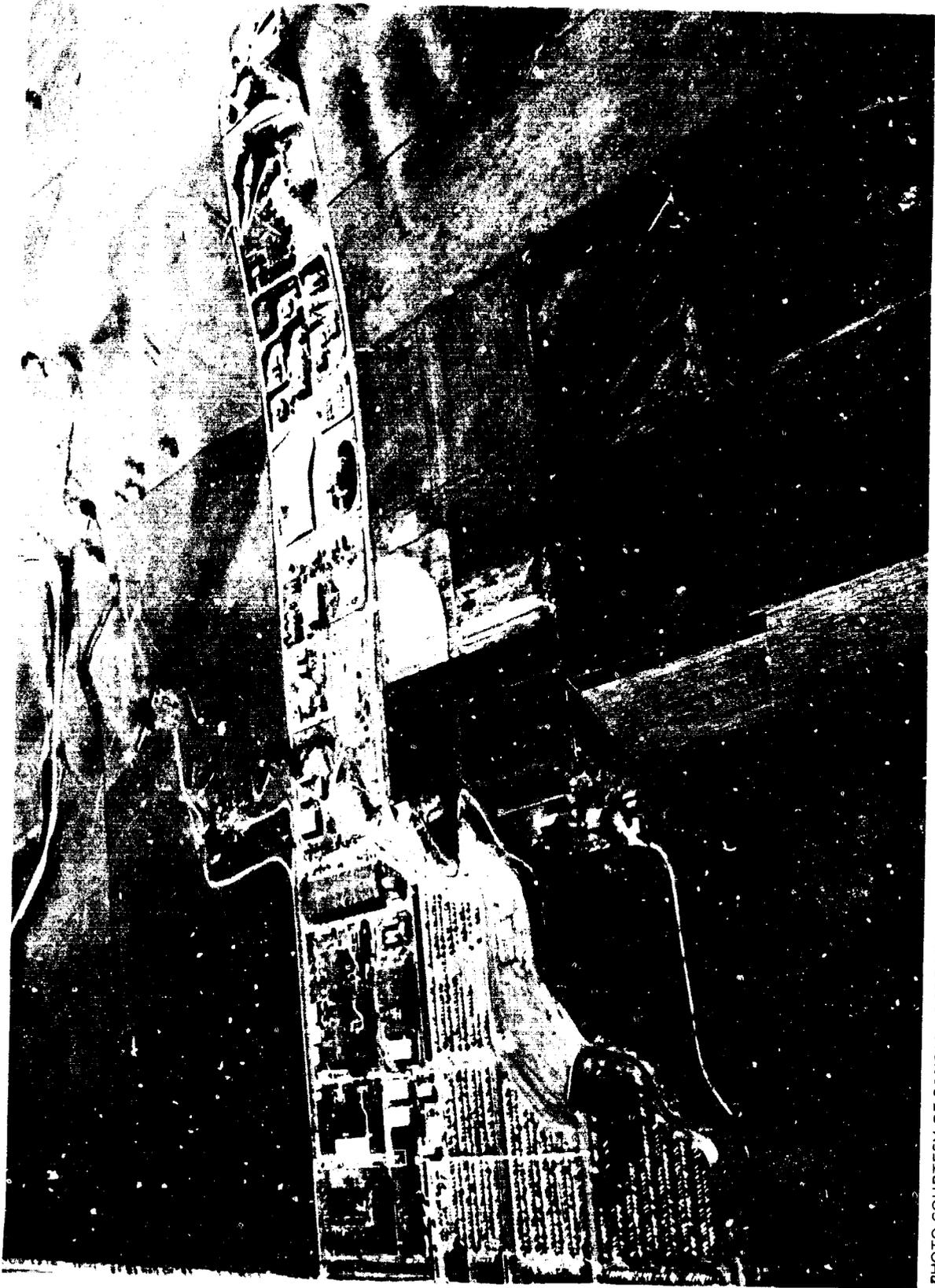


PHOTO COURTESY OF SANDIA LABORATORIES

SANDIA LABORATORIES COMPLEX LOCATED AT LIVERMORE, CALIFORNIA.

drilling techniques, extraction of energy from coal and magma (molten rock), and solar- and wind-energy systems.

Sandia operates accelerators; pulse reactors; a neodymium-glass laser; testing facilities for various aspects of weapons; a computer facility; facilities for the design, fabrication, and process development of weapons; and laboratories for measurement standards and for microcircuitry and semiconductor techniques. Several other facilities have been approved for construction at Sandia, including a 5-megawatt solar test facility scheduled for completion in fiscal year 1978.

Nuclear energy and life sciences laboratories

Argonne, Oak Ridge, and Pacific Northwest can be considered nuclear energy and life sciences laboratories although each has large efforts in other areas. Argonne and Oak Ridge have major efforts in nuclear reactor development and Pacific Northwest has major efforts in the nuclear fuel cycle. They each have major efforts in environmental research. Argonne and Oak Ridge also have major efforts in basic research and each of the laboratories is involved in magnetic fusion; fossil, solar, and geothermal energy; conservation; national security; and biomedical efforts. These laboratories currently report to the Under Secretary, but DOE is considering alining them to an Assistant Secretary responsible for an energy RD&D program.

The laboratories carry out a small portion of their work efforts for others, primarily other Federal agencies. In line with their major efforts in nuclear energy RD&D, the bulk of this work is for the Nuclear Regulatory Commission in areas such as nuclear facility siting, safeguards, licensing, and regulation. The laboratories also perform work for other Federal agencies such as the Environmental Protection Agency, the National Institutes of Health, NSF, and DOD.

Table 4 shows the laboratories' fiscal year 1977 funding outlays, capital investment, and staffing.

Table 4
Nuclear Energy and Life Sciences
Laboratories' Outlays, Capital Investment
and Staffing for Fiscal Year 1977

	<u>Argonne</u>		<u>Oak Ridge</u>		<u>Pacific Northwest</u>	
	<u>Amount</u>	<u>Percent of total</u>	<u>Amount</u>	<u>Percent of total</u>	<u>Amount</u>	<u>Percent of total</u>
<u>Outlays</u> (millions) (note a)						
National security	\$ 3.1	1.7	\$ 0.2	0.1	\$ 3.0	4.9
Nuclear energy	84.4	46.5	93.1	47.6	25.8	42.1
Nonnuclear energy:						
Fossil	9.8	5.4	7.7	3.9	0.8	1.3
Solar	2.5	1.4	0.9	0.5	4.9	8.0
Geothermal	(b)	(c)	1.1	0.6	2.4	4.0
Conservation	12.4	6.8	4.5	2.2	1.3	2.1
Environment and safety	19.2	10.5	31.8	16.3	19.6	32.0
Basic science	47.7	26.3	48.6	24.9	3.4	5.6
Program support	1.2	0.7	0.8	0.4	-	-
Work for others (note d)	1.3	0.7	6.9	3.5	(b)	(c)
Total	<u>\$181.6</u>	<u>100.0</u>	<u>\$195.5</u>	<u>100.0</u>	<u>\$61.2</u>	<u>100.0</u>
<u>Cumulative capital investment</u> (millions) (note e)	<u>\$544.7</u>		<u>\$457.3</u>		<u>\$64.4</u>	
<u>Staffing (3/31/77)</u>						
Engineering	707	14.4	795	15.1	323	15.4
Physical and chemical science	707	14.4	609	11.5	258	12.3
Mathematics and computer science	134	2.7	101	1.9	34	1.6
Life and environmental science	142	2.9	263	5.0	188	9.0
Social sciences	13	0.3	40	0.8	21	1.0
Other professional and support staff	3,213	65.3	3,468	65.7	1,268	60.6
Total	<u>4,916</u>	<u>100.0</u>	<u>5,276</u>	<u>100.0</u>	<u>2,092</u>	<u>100.0</u>

a/Includes operating and capital plant and equipment outlays.

b/Less than \$.05 million.

c/Less than .05 percent.

d/Primarily work funded by other Federal agencies.

e/Capital investments authorized through fiscal year 1977.



PHOTO COURTESY OF ARGONNE
NATIONAL LABORATORY

ARGONNE NATIONAL LABORATORY, DARIEN, ILLINOIS

Argonne National Laboratory

Argonne is located near Chicago, Illinois, and has a second nuclear reactor development site at DOE's Idaho National Engineering Laboratory near Idaho Falls, Idaho. Argonne is Government-owned, but jointly operated by the University of Chicago and Argonne Universities Association, a consortium of 30 midwest universities (see app. I).

Argonne's current efforts are in the development of nuclear and other energy sources and in fundamental biomedical, environmental, and physical research. Development of the liquid metal fast breeder reactor is the focus of the largest single effort at Argonne and comprises a number of coordinated efforts. Argonne designed and constructed several nuclear test reactors which it now operates and has major responsibility for fast reactor physics and safety. Major facilities include a large particle accelerator and reactor test facilities. It performs nonnuclear energy work in solar energy, batteries, magnetic fusion, and coal-related work in fluidized-bed combustion and magnetohydrodynamics. Argonne has strong capabilities in computer science, in energy and environmental studies, and in design and fabrication of large superconducting magnets.

Oak Ridge National Laboratory

Located in Oak Ridge, Tennessee, this laboratory is operated by the Nuclear Division of Union Carbide Corporation. Its major efforts are in reactor development; nuclear, atomic, and molecular physics; magnetic fusion; metallurgy; materials science; biology; environmental sciences; and a broad-based information system. Its nonnuclear work includes coal-conversion techniques, including biomedical and environmental studies; solar energy; energy conservation, including energy conversion and low-temperature heat utilization; and research in carcinogenesis, chemical mutagenesis, and bioengineering.

Oak Ridge operates three major magnetic fusion devices, several research reactors, the Transuranium Processing Plant for separating heavy elements, six accelerators, a Thorium-Uranium Recycle Facility for remotely processing reactor fuels, and a biological laboratory complex. Currently being constructed are a heavy ion research facility, scheduled for completion in 1979, and an environmental sciences laboratory which is to be completed in 1978.

Pacific Northwest Laboratory

Located in Richland, Washington, Pacific Northwest is operated by Battelle Memorial Institute. Battelle's privately developed research complex and the Government-owned facilities

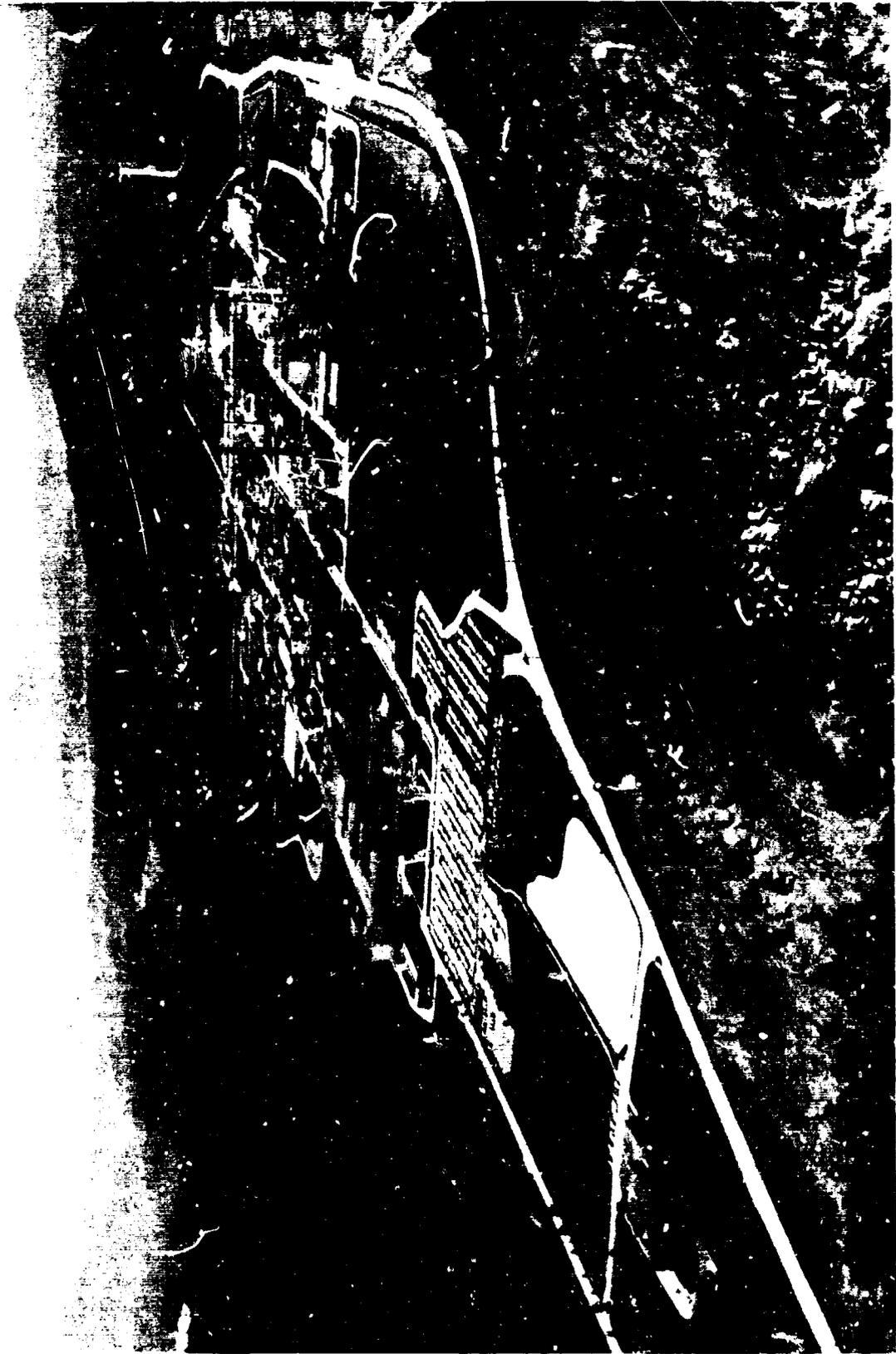


PHOTO COURTESY OF OAK RIDGE
NATIONAL LABORATORY

OAK RIDGE NATIONAL LABORATORY, OAK RIDGE, TENNESSEE



PHOTO COURTESY OF PACIFIC NORTHWEST
LABORATORY

PACIFIC NORTHWEST LABORATORY COMPLEX LOCATED AT RICHLAND, WASHINGTON



PHOTO COURTESY OF PACIFIC
NORTHWEST LABORATORY

PACIFIC NORTHWEST LABORATORY FACILITIES LOCATED AT HANFORD, WASHINGTON

are operated as a consolidated laboratory. Staff and material resources of Pacific Northwest and Battelle are consolidated for operating purposes. Battelle and DOE have established a cost accounting system which is designed to allocate costs to the applicable sponsoring organization.

The laboratory's principal areas of effort are the nuclear fuel cycle and biomedical and environmental research. It also has RD&D activities in magnetic fusion, solar energy, fossil energy, basic energy sciences, energy conservation, geothermal energy, and weapons. Its principal facilities include two life sciences laboratories, aquatic laboratory facilities, radiochemistry laboratories, and radiation counting facilities. Pacific Northwest also conducts research on the Hanford National Environmental Research Park which includes a 120-square-mile site dedicated to basic ecological research.

Fundamental research laboratories

The Brookhaven and Lawrence Berkeley Laboratories work predominately in the basic physical and materials sciences and are aligned to the Office of Energy Research. They each have special facilities to accommodate such work and much of their efforts make extensive use of these facilities. The laboratories have applied the results and techniques gained from their basic research work to the former ERDA's and DOE's efforts in magnetic fusion, biology and medicine, environmental research, solar energy, geothermal energy, conservation, fossil energy, nuclear energy, and weapons.

The two laboratories carry out a small amount of work for others, primarily other Federal agencies. Much of this has been life sciences work funded by the Department of Health, Education, and Welfare and the Environmental Protection Agency. Brookhaven also had some work in nuclear reactor safety funded by the Nuclear Regulatory Commission and Lawrence Berkeley provided computer support services to DOD.

Table 5 shows the fundamental research laboratories' fiscal year 1977 funding outlays, capital investment, and staffing.

Table 5
Fundamental Research Laboratories'
Outlays, Capital Investment, and
Staffing for Fiscal Year 1977

	<u>Brookhaven</u>		<u>Lawrence</u>	<u>Berkeley</u>
	<u>Amount</u>	<u>Percent of total</u>	<u>Amount</u>	<u>Percent of total</u>
<u>Outlays</u> (millions) (note a)				
National security	\$ 1.0	1.0	\$ 0.3	0.4
Nuclear energy	3.1	3.3	3.5	5.3
Nonnuclear energy:				
Fossil	1.0	1.0	0.7	1.1
Solar	1.1	1.2	1.2	1.8
Geothermal	0.5	0.5	4.4	6.7
Conservation	7.3	7.7	3.2	4.9
Environment and safety	19.9	21.1	12.2	18.5
Basic science	58.5	61.9	39.6	60.1
Program support	2.1	2.3	0.3	0.4
Work for others (note b)	<u>(c)</u>	<u>(d)</u>	<u>0.5</u>	<u>0.7</u>
Total	\$ <u>94.5</u>	<u>100.0</u>	\$ <u>65.9</u>	<u>100.0</u>
<u>Cumulative capital investment</u> (millions) (note e)	<u>\$367.5</u>		<u>\$178.0</u>	
<u>Staffing (3/31/77)</u>				
Engineering	244	8.0	226	8.7
Physical and chemical science	418	13.6	423	16.4
Mathematics and computer science	69	2.2	128	5.0
Life and environ- mental science	138	4.5	71	2.7
Social science	19	0.6	-	-
Other professional and support staff	<u>2,180</u>	<u>71.1</u>	<u>1,736</u>	<u>67.2</u>
Total	<u>3,068</u>	<u>100.0</u>	<u>2,584</u>	<u>100.0</u>

a/Includes operating and capital plant and equipment outlays.

b/Primarily work funded by other Federal agencies.

c/Less than \$.05 million.

d/Less than .05 percent.

e/Capital investments authorized through fiscal year 1977.



PHOTO COURTESY OF BROOKHAVEN
NATIONAL LABORATORY.

BROOKHAVEN NATIONAL LABORATORY, UPTON, NEW YORK

Brookhaven National Laboratory

Located in Upton, Long Island, New York, Brookhaven is operated by Associated Universities, Inc., a consortium of nine eastern universities (see app. I). Brookhaven's principal efforts are in the fundamental research of matter, basic energy science, effects of radiation and chemical substances involved in the production and use of energy, and energy systems. It operates a large particle accelerator, the Alternating Gradient Synchrotron; other small accelerators; and research reactors. It has large staffs devoted to reactor safety, materials and molecular sciences, plant physiology, hematology, bubble chamber research and development, studies of bioenvironmental impact of offshore powerplant siting, and advanced use of computers.

Brookhaven's principal energy efforts are in energy systems analysis and support. Most of these efforts are in energy conservation and fusion, with moderate efforts in solar and fossil energy.

Lawrence Berkeley Laboratory

Located in Berkeley, California, this laboratory is operated by the University of California. It is the principal U. S. laboratory in the field of heavy ion research. Its major research efforts are in high- and medium-energy physics, nuclear chemistry, materials science, radiobiology of heavy ions, photobiology, molecular biology, nuclear medicine diagnosis and treatment, and detection of environmental pollutants and their effects. Lawrence Berkeley operates a heavy-ion facility for biomedicine and physics and several accelerators. Its energy RD&D efforts include magnetic fusion; solar energy; conservation; geothermal power from hydrothermal reservoirs; and production of clean fuels from coal, cellulose, and water.

MULTIPROGRAM LABORATORIES' NON-NUCLEAR ENERGY RD&D ACTIVITIES ARE OFTEN SMALL AND FRAGMENTED

In fiscal year 1976, including the transition quarter, the multiprogram laboratories' efforts in nonnuclear energy RD&D --fossil energy, solar energy, geothermal energy, and conservation--totaled \$91.4 million or 16.6 percent of ERDA's outlays for these nonnuclear energy areas. Of this amount, \$87 million was for operating outlays, with the balance of \$4.4 million for capital outlays. Our analysis of these operating outlays, which represented less than 9 percent of the laboratories' total outlays, showed that responsibility for carrying out the tasks of the various nonnuclear programs was scattered among the eight multiprogram laboratories.



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BERKELEY LABORATORY.

LAWRENCE BERKELEY LABORATORY, BERKELEY, CALIFORNIA

The primary vehicle for the laboratories to obtain work tasks to carry out is Schedule 189, "Additional Explanation for Operating Costs-Research Development and Process Development Activities," or its equivalent, commonly referred to as the "Form 189." Under the Form 189 system, the laboratories usually initiate ideas for future work; discuss their ideas with headquarters program managers; and, if acceptable to those program managers, the laboratories prepare individual Form 189s for specific RD&D areas and classify them under the various DOE budget categories. The Form 189s describe major achievements and research planned for the budget year and projected for the year following the budget year. Each Form 189 research area consists of one or more individual RD&D tasks. The Form 189s approved for funding during the annual budget process constitute the laboratories' workload for that budget year. Table 6 shows a breakout of the operating outlays and the number of Form 189s by laboratory.

Table 6

Multiprogram Laboratory Participation in
Nonnuclear Energy RD&D for Fiscal Year 1976 (note a)

Multiprogram laboratory	Fossil		Solar		Geothermal		Conservation		Total nonnuclear	
	No. of 189s	Operating outlays (millions)	No. of 189s	Operating outlays (millions)						
Lawrence Livermore	3	\$ 7.6	3	\$ 0.7	1	\$ 4.8	17	\$ 1.6	19	\$14.7
Los Alamos	1	0.4	14	1.2	8	6.6	5	2.4	28	10.6
Sandia	17	5.4	18	10.0	6	1.8	14	1.3	55	18.5
Argonne	13	10.2	4	0.9	1	0.1	20	8.4	38	19.6
Oak Ridge	24	4.8	3	0.4	4	0.9	15	2.5	46	6.6
Pacific Northwest	3	0.3	8	1.0	6	2.4	7	1.0	24	4.7
Brookhaven	3	0.7	2	0.2	2	0.2	12	4.6	19	5.7
Lawrence Berkeley	4	0.1	11	1.3	13	2.4	7	0.7	35	4.5
Total: (note b)	68	\$29.5	63	\$15.7	41	\$19.3	92	\$22.5	264	\$87.0
Average outlays per 189		\$0.43		\$0.25		\$0.47		\$0.25		\$0.33

a/Includes transition quarter.
b/May not add due to rounding.

Officials at some of the laboratories told us that many of the tasks assigned to the laboratories in nonnuclear energy RD&D are of limited scope and closely monitored by headquarters program managers. They stated that these limited tasks inhibit the laboratories from having the flexibility to develop alternative solutions to energy problems.

Within each of the nonnuclear energy areas shown, Form 189s were further scattered among a number of technologies. For example, 16 of the 63 solar energy Form 189s were for tasks in the solar heating and cooling R&D program element which were carried out by six multiprogram laboratories. This program element is one of three elements in the solar heating and cooling of buildings category, a component of the Solar Thermal Applications subprogram. The six laboratories' total outlays for these 16 tasks during fiscal year 1976, including the transition quarter, amounted to about \$1.3 million. This represented about 17 percent of ERDA's total outlays of \$7.5 million for the 75 tasks it supported under this program element during the period. Industry, universities, nonprofit institutions, and other Federal agencies carried out the other 59 tasks.

MULTIPROGRAM LABORATORIES' TECHNICAL
CAPABILITIES HAVE BEEN APPLIED TO
NONNUCLEAR ENERGY TECHNOLOGIES

We examined selected ongoing nonnuclear energy tasks at the laboratories to determine if they actually had capabilities which could be applied to nonnuclear energy RD&D. We selected the largest nonnuclear energy RD&D tasks and those tasks for which university or industry officials expressed concern over the bases for using the laboratories. We examined 76 tasks, for which the eight multiprogram laboratories' fiscal year 1976 outlays totaled \$40.2 million, or about 66 percent of their total fiscal year 1976 nonnuclear energy RD&D operating outlays. Through discussions with headquarters program managers and laboratory officials and by reviewing documents they provided, we found that in each of these cases some laboratory capabilities existed when the laboratories were selected to undertake these tasks. On the basis of the information obtained, we categorized the principal reasons for selecting the laboratories for these tasks as shown in table 7.

Table 7

Principal Reasons for Multiprogram
Laboratory Involvement in 76 Selected Tasks

<u>Reason for selection</u>	<u>Number of tasks</u>	<u>Percent of total</u>
Laboratory had existing capability from similar work in other programs	38	50.0
Laboratory had existing capability from related work in same program	31	40.8
ERDA headquarters needed technical support	<u>7</u>	<u>9.2</u>
Total	<u>76</u>	<u>100.0</u>

Table 7 shows that ERDA program managers chose the laboratories to undertake 69 of the 76 tasks primarily because the laboratories had existing capabilities. In 38 of these cases the laboratories applied expertise developed in carrying out other similar activities, and in the other 31 cases this capability was developed in related work in the same program. However, we noted that the laboratories expanded their capabilities in carrying out these tasks by both shifting staff and hiring additional staff.

For example, in 1974 two scientists at Lawrence Livermore proposed work on the packed-bed concept of in situ coal gasification, and AEC approved the proposal in fiscal year 1975. This concept is to use chemical explosives in an array of drilled holes to fracture coal at depths from 500 to 3,000 feet. The coal in the fractured bed would be gasified with steam and oxygen, as in conventional high-Btu gasification, and the gases produced underground would be treated in a surface facility to produce pipeline-quality gas. The laboratory initiated its work on this concept using capabilities developed in the former AEC's "plowshare" program, which explored the peaceful uses of nuclear explosives, including possible applications to geothermal, oil shale, coal gasification, and solar technologies.

Lawrence Livermore's outlays for this task amounted to \$3.4 million in fiscal year 1975 and about \$3.5 million in fiscal year 1976, but with the Administration's change in emphasis to near-term technologies, outlays were reduced to \$2.7 million in fiscal year 1977. In fiscal year 1977 Lawrence Livermore had 26 professional and 4 technicians directly

assigned to work on this task. Hence, the laboratory initiated work using existing capabilities of two professionals in 1974, but had built on that capability to carry out the work.

As the laboratories increased their capabilities in non-nuclear energy RD&D, ERDA headquarters program managers relied more heavily on them for needed technical support, such as technical studies and project management tasks. The technical studies include broad studies such as an analysis of the role of fossil energy systems in the context of the U. S. energy system and narrowly-defined studies such as a detailed evaluation of fabrication methods for axis motion mechanisms in reflectors used in solar thermal collectors. Project management tasks assigned to the laboratories included: reviewing unsolicited proposals, visiting contractor sites, reviewing contractor progress reports, assisting in the preparation and evaluation of Requests for Proposals, and developing program plans. Seven of the 76 tasks we reviewed were for technical support requirements initiated by ERDA headquarters program managers.

Another important, though not a principal reason for assigning several of these tasks to the laboratories, was that ERDA headquarters program managers believed that these tasks were inappropriate for industry or universities to carry out. For example, one task for developing energy conservation performance standards for buildings was awarded to Lawrence Berkeley. According to ERDA, several industrial firms were capable of carrying out this task. However, ERDA's Division of Conservation believed this would be inappropriate since the division wanted a wide distribution of such standards, but the industrial firms wanted the patent rights. In addition, the division feared industry did not want such standards set and that standards developed by industry may be set too low.

Thus, our examination indicated that the multiprogram laboratories have some existing technical capabilities that, while they may require augmentation to allow them to undertake certain tasks, appear to be well suited for nonnuclear energy RD&D.

The capabilities of the multiprogram laboratories to carry out nonnuclear energy RD&D were also recognized in a December 1975 report by ERDA's Field and Laboratory Utilization Study Group. The purpose of that study was to evaluate the management practices inherited by ERDA from other organizations and make recommendations that might contribute to the best use of existing field and laboratory resources in accomplishing ERDA's mission. The Study Group concluded that the multiprogram laboratories' capabilities in nonnuclear energy areas warranted

giving them major mission assignments in such areas. The pertinent section of the Study Group's report is quoted below:

"With the change in the Atomic Energy Act in 1972, the multi-program laboratories were strongly encouraged to enter into AEC-supported work in the non-nuclear energy area. Their achievements to date, as exemplified by progress in geothermal energy, in situ coal gasification, solar thermal energy, analysis of energy systems, and applications of high technology developments such as super-conductivity to energy have been impressive for the efforts invested. The major activities of the multi-program laboratories continue to be in nuclear-related research and development and in long-range research, both of which are important and are statutory responsibilities of ERDA. Their skills and disciplines, as well as some related experience, can be directly applied to the non-nuclear energy-related challenges. The flexibility inherent in a Government-owned, contractor-operated operation, with a broad technology base, gives the laboratories the ability to marshall broad technical project teams to concentrate on specific complex scientific and technological problem areas. The laboratories, therefore, should be assigned major missions in non-nuclear areas."

Although the multiprogram laboratories have technical capabilities that can be applied to nonnuclear energy RD&D, we noted that their capabilities in the socioeconomic areas appeared to be somewhat limited. As of March 31, 1977, the total number of professional employees at the eight multiprogram laboratories was 12,989. Of these employees, about 120, or about 1 percent, had backgrounds in social science; 1,048, or about 8 percent, in the life sciences; and about 11,300, or about 87 percent, in engineering, physics, chemistry, or mathematics. Hence, the laboratories' professional staffs are primarily technically-oriented; and, to the extent that they may eventually be assigned nonnuclear energy missions, it appears that they lack the educational background to assess and provide solutions to the socioeconomic issues that may impede the widespread use of nonnuclear energy technologies assigned to them.

In examining ERDA's infrastructure for addressing such issues, we noted that headquarters and field operations offices personnel similarly lack the capabilities to address such issues. In some cases, headquarters program managers have turned to the laboratories for such assistance. For example, ERDA turned primarily to its laboratories to consider the appropriate sites for energy facilities. In assessing

such sites, the whole range of socioeconomic issues usually must be considered. However, some concern has been expressed as to whether the laboratories can effectively deal with these issues. In this regard, in its assessment of ERDA's plans and programs, the Office of Technology Assessment (OTA) ^{1/} questioned whether the laboratories should appropriately conduct such assessments. OTA pointed out that critics argue that the laboratories simply provide briefs to underpin their siting decisions and concluded that ERDA should obtain support from other research groups.

We agree that such tasks should not be carried out by entities which lack the essential capabilities. However, we believe that the laboratories should build up such capabilities so that they may properly carry out their efforts in energy technology development. To achieve widespread use of a new technology in the marketplace, it not only needs to be developed technically, but its environmental, economic, social, political, and legal impacts must be assessed and resolved. Without such an integrated holistic approach to technology development, a new technology's introduction to the marketplace is likely to fail or be delayed. Accordingly, if the laboratories are to be assigned nonnuclear energy RD&D missions, we believe that the laboratories must have the capability for integrating the socioeconomic issues with the technical aspects to provide the needed holistic approach.

^{1/}Comparative Analysis of the 1976 ERDA Plan and Program, Office of Technology Assessment, May 1976.

CHAPTER 3

FACTORS LIMITING THE ROLES OF

THE MULTIPROGRAM LABORATORIES

As discussed in the preceding chapter, ERDA's Field and Laboratory Utilization Study Group concluded that the multiprogram laboratories should be assigned major missions in nonnuclear energy areas. Although ERDA had initiated actions designed to assign such missions and DOE is continuing work on those initiatives, we found that such missions had not yet been assigned and that laboratory roles in nonnuclear energy RD&D had not been adequately defined. In this regard, DOE officials advised us that these mission assignments are expected to evolve over the next few years. ERDA had criteria for delineating the roles of the multiprogram laboratories in the various phases of energy RD&D, but these criteria were informal and too generalized to adequately define the laboratories' roles in nonnuclear energy RD&D.

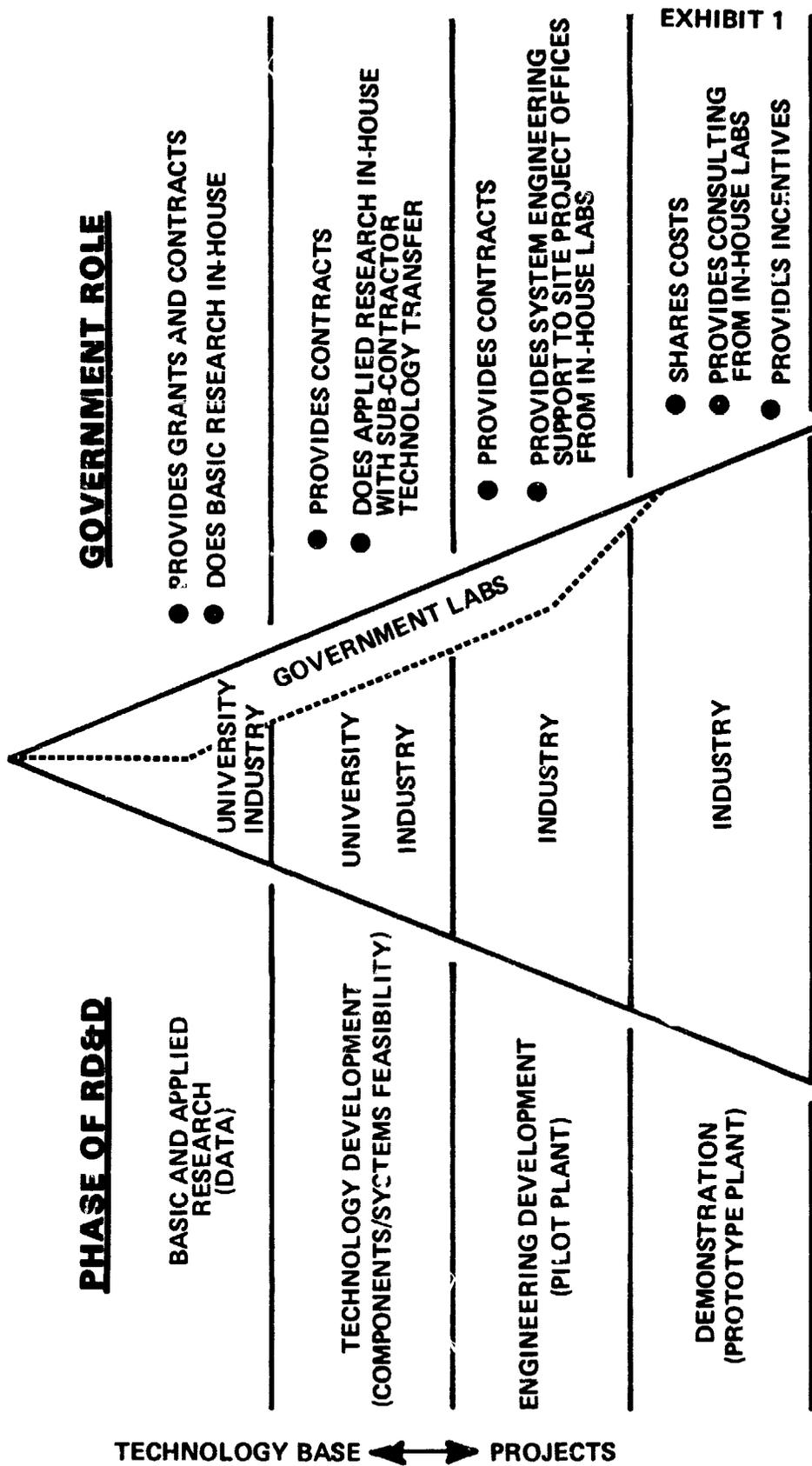
ERDA had proposed a system for integrating its program planning, budgeting, and review processes, with participation from the multiprogram laboratories, and had issued the requirement for its implementation on July 20, 1977. Such implementation was scheduled to occur during the fiscal year 1979 budget process. However, DOE replaced ERDA's system with a new system, described later in this chapter, which incorporates portions of ERDA's system and is scheduled to be implemented for the fiscal year 1980 budget process.

In the absence of clear role definitions, we identified several major factors which have limited the laboratories' involvement in these efforts. In addition, we noted that DOE's organizational alinement of the laboratories is not conducive to their optimal use in nonnuclear energy RD&D.

INFORMAL CRITERIA ON THE ROLE OF THE MULTIPROGRAM LABORATORIES

During our review, an ERDA official responsible for overseeing the use of the laboratories advised us that there were no formal criteria for assigning RD&D work to the laboratories. He pointed out, however, that the degree to which laboratories should participate in the various phases of RD&D--fundamental research, technology development, engineering development, and demonstration--should diminish and industry's role should increase as work progresses from R&D to commercialization. He provided us with the diagram shown in exhibit 1 (see p. 38) to illustrate this viewpoint.

Informal Criteria for Participation of Government, University, and Industry in Performing RD&D



Officials at the eight multiprogram laboratories advised us that they agree with these informal criteria and generally contended that the criteria are being followed at the laboratories.

While many university and industry officials involved in energy RD&D that we contacted also agreed with these criteria, some of them believed the criteria are unworkable because they are too general for practical purposes. They pointed out that there is no clear delineation between the various phases of RD&D and that there is a tendency by the laboratories, which is intrinsic to any organization, to try to extend their roles.

Our review showed that there are no clear cut definitions of the various RD&D phases. The categorization of a given activity into a RD&D phase is based on the judgments and perceptions of those making such a categorization. For example, ERDA and the Mitre Corporation, under a contract with ERDA, each conducted an analysis of the ERDA fiscal year 1976 funds for solar and geothermal energy work and categorized the activities associated with this funding in the various phases of RD&D. These analyses, which are summarized in table 8, showed wide differences in the judgments or perceptions relative to the phases of the activities.

Table 8

Categorization by RD&D Phase of
Fiscal Year 1976 ERDA Funded
Solar and Geothermal Energy Work

	<u>Basic and</u> <u>applied</u> <u>research</u>	<u>Technology</u> <u>development</u>	<u>Engineering</u> <u>development</u>	<u>Demonstration</u>
	------(percent of total)-----			
Solar:				
ERDA	-	69	-	31
Mitre Corp.	-	5	56	39
Geothermal:				
ERDA	-	67	33	-
Mitre Corp.	-	36	64	-

We generally agree with the underlying concept of ERDA's informal criteria because we believe industry participation should increase as a technology's development progresses to facilitate its acceptance in the marketplace. However, in our opinion, these criteria do not provide a sufficient basis

for delineating the roles of the multiprogram laboratories because these criteria are not well-defined and do not specify the technologies in which each laboratory should be performing its work.

ERDA'S PROGRAM PLANNING, BUDGETING,
AND REVIEW SYSTEM NOT IMPLEMENTED

In response to the requirements of the Energy Reorganization Act of 1974, ERDA issued in June 1975 its first national plan, "A National Plan for Energy Research, Development, and Demonstration: Creating Energy Choices for the Future (ERDA-48)." The plan was to help coordinate and integrate energy RD&D programs to meet national needs. The plan pointed out that energy planning must evolve through additional stages requiring (1) a thorough analysis of key uncertainties to confirm or modify priorities and (2) a more integrated treatment of programs to allow for precise definition of programs to ensure that each program responds to its greatest opportunities and produces results directly in support of national goals. To accomplish this additional planning, ERDA proposed a Program Planning, Budgeting, and Review (PPBR) system.

The objective of the PPBR system was to provide an integrated and disciplined approach to analyzing the Nation's future energy needs. One of the key aspects of this proposed system was to provide a framework for determining the role of each multiprogram laboratory in various RD&D areas.

The system was designed to be a "top-down" management system with each major phase structured to build upon the output of the preceding phase. The six major phases were (1) normative planning, (2) strategic planning, (3) program and environmental planning, (4) resource allocation, (5) program implementation, and (6) review and evaluation.

The normative planning phase aimed toward establishing goals and identifying preferred solutions to the national energy problem. ERDA executed this phase each year and issued annual plans.

Strategic planning was to define how the goals developed during the normative planning phase can be achieved most effectively. Specific energy options, the extent of Federal participation, and constraints to market penetration were to be addressed in detail in a strategic planning document for each of ERDA's major programs. Before ERDA's disbandment in September 1977, strategic planning documents had been drafted on a test basis for 8 of the approximately 40 major programs for which these plans were expected to be prepared, and only 1, covering enhanced oil recovery was issued as a final ERDA document.

According to an official in the Office of Planning, Analysis, and Evaluation, the ERDA Administrator did not approve seven of the documents because they did not adequately address the issues for which the documents were designed. The balance of about 32 strategic planning documents that were expected to be prepared were never initiated.

Program planning was the first phase in which the role of ERDA's field institutions, including the multiprogram laboratories, was to be delineated. Program plans were to set forth the means by which strategic plans were to be accomplished and serve as input to resource allocation, program implementation, and program evaluation activities. Environmental development plans were expected to accompany program plans to ensure that environmental, social, and institutional implications are considered in each technology. Annually updated 5-year institutional plans were to be prepared for each laboratory to show its intended use in accomplishing the program and environmental development plans. At the time of ERDA's demise in September 1977, none of the required program plans and only 3 of the expected 34 environmental development plans were issued. Although 17 institutional plans were being drafted by the laboratories, none of these had been issued by ERDA.

Resource allocation, essentially the annual budget process, was to be based on strategic and program plans. Although the budget process, of course, was carried out each year, in the absence of strategic and program plans, the process was carried out in the nature of a "bottom-up" approach to resource allocation. In this process the field operations offices and laboratories annually provided, in response to a call from the ERDA Controller for a field budget, descriptions and funding requirements for the proposed tasks that the laboratories and major contractors wanted to undertake in the upcoming budget year.

Each laboratory submitted its proposed budget to its cognizant field operations office, which reviewed the laboratory's total budget and performance capabilities for proposed projects and recommended whether the projects be approved. The field operations offices submitted these field inputs to the Office of the Controller, which in turn provided the applicable data to the cognizant divisions. The program divisions considered these field inputs in formulating program budget requests for their respective divisions.

The Offices of the Controller and Planning, Analysis, and Evaluation reviewed and evaluated these program division budget requests and prepared program budget issue documents on each of the basic issues. These budget requests and issue documents were submitted to the Budget Review Committee for its review,

modification, and ultimate approval for submission to the ERDA Administrator. This Committee was chaired by the Deputy Administrator and its primary members were ERDA's six program Assistant Administrators, with other staff administrators, such as the Controller, in staff roles.

Program implementation planning activities delineated the specific tasks to be accomplished within approved funding levels. This phase was in place with annual Program Approval Documents issued which described planned tasks, set forth milestones, and prescribed the steps and methods to be taken to achieve milestones. The purpose of these documents was to provide a baseline for monitoring program operations during a given fiscal year.

During the review and evaluation phase, the ERDA Administrator each month selected certain programs and evaluated their progress in relation to their plans. During a 1-year cycle, each major program was to be reviewed at least once. This evaluation process was formally established in June 1977 and, according to an official in ERDA's Office of Planning, Analysis, and Evaluation four programs had been reviewed before ERDA's demise: magnetic fusion, security and safeguards, inertial confinement fusion, and environment and safety.

During our review we noted that the PPBR system had been under development for more than 2 years, and at the time of ERDA's demise, the system was still not in place. Commenting on the lengthy time frame required to develop and implement the system, an official in ERDA's Office of Planning, Analysis, and Evaluation told us that the problem was a lack of overall management emphasis on planning. He said that ERDA's management had been primarily concerned with budgeting because the rewards are in this area. He pointed out that this is generally true throughout Government in that there are no rewards or punishments for good or bad planning. This official said that another factor which had delayed the implementation of the PPBR system was the reluctance of ERDA program offices to change their procedures. He explained that each program office believed that its program had unique requirements and the procedures had to be negotiated with each program office before they could be issued.

Although on July 20, 1977, ERDA issued a manual chapter requiring the complete implementation of the PPBR system, ERDA officials pointed out that such implementation was scheduled for the fiscal year 1979 budget process, which was already underway. They explained that they had proceeded with the requirement in the hopes that DOE would adopt the PPBR system or some version of it. However, upon commencement of operations

in October 1977, DOE discontinued the implementation of ERDA's proposed PPBR system and began developing a new system.

In October 1977, a DOE official, working on the development of the new system--DOE Policy and Program Planning System--told us that the new system adopts certain aspects of ERDA's PPBR system, such as program approval documents, but is essentially a completely different system than that which ERDA tried to initiate. This official explained that the ERDA system was being developed primarily for RD&D, whereas DOE's system has to accommodate the needs of the entire organization--including the functions transferred from other Federal agencies. This official pointed out that the DOE system will further develop and evolve as DOE gains experience and that modifications may be necessary to make the system more responsive to management's needs. According to this official, the system is to be implemented during the preparation of the fiscal year 1980 budget.

DOE's October 3, 1977, Interim Management Directive, describes the new system as encompassing three major phases; (1) policy development, (2) program and budget review, and (3) program implementation and evaluation. The policy development phase is to include an assessment of the energy situation and the effect of DOE's plans and programs. A biennial National Energy Policy Plan is to be developed to express the energy policy and an annual Policy and Fiscal Guidance is to be developed to provide the basis for program planning in the program and budget review phase. Program plans are to be developed by DOE line managers and be reviewed and approved by the Secretary in the annual budget process. These plans are to describe the program objectives and strategy over an as yet undetermined number of years and set forth the criteria to be used in evaluating program effectiveness. Annual Management Review and Control Documents are to be prepared by line managers to facilitate program implementation and review.

According to the interim directive, in the program implementation and evaluation phase, evaluations of program performance, efficiency, and effectiveness are to be conducted by the various managers responsible for implementing the programs and by the Assistant Secretary for Policy and Evaluation. Management review is to be performed by a Management Review Board which is to be chaired by the Deputy Secretary or Under Secretary and consist of staff and line officers to be determined by the Chairman. This board is to meet periodically to review program performance against scheduled milestones and to discuss issues arising from program implementation.

This system is designed to provide an overall framework for program planning and budgeting. We noted that the interim directive describing the new system did not address the

development of institutional plans, which ERDA designed to help define the role of the laboratories. However, in January 1978 DOE formally decided to adopt the institutional plans. A DOE official told us that the 17 institutional plans, initiated by ERDA have been prepared and are being used informally, but that formal procedures for their integration and use within DOE's Policy and Program Planning System have not yet been developed.

In this regard, DOE officials told us they are in the process of integrating the institutional plans into the system and the plans are expected to be used in formulating the fiscal year 1980 DOE budget. However, these officials said that it will take some time to fully integrate these plans into the system. They explained that when fully integrated into the system the plans are to set forth each laboratory's roles, including mission assignments; but that they face the practical problem of making such assignments. They said that, while they are fully aware of each laboratory's capabilities, they must decide which technology base areas should be assigned to each laboratory; how large these assignments should be; what levels of duplication, if any, are desirable; how such assignments will impact on universities' and industry's roles; and a host of other practical problems which arise in making such assignments.

While the informal use of the institutional plans on an interim basis should help management by providing visibility over the laboratories' activities, we believe that to enhance their usefulness, these plans should be fully integrated into DOE's Policy and Program Planning System as soon as possible. In developing its system to integrate planning, programming, and budgeting, ERDA met resistance from its program managers in accepting new procedures and in attaining concurrence on the details of implementation. After being in existence nearly 3 years, ERDA's system was still not in place and that portion of the system which was to help define and integrate the laboratories' roles into ERDA's overall planning system was never accomplished. Unless appropriate management attention and emphasis are given, DOE may similarly encounter resistance and problems which would delay the implementation of its system, even though it has adopted the institutional plans.

FACTORS LIMITING MULTIPROGRAM LABORATORIES' ROLES IN NON- NUCLEAR ENERGY RD&D

In the absence of clearly delineated roles for the multiprogram laboratories in nonnuclear energy RD&D, their roles in such RD&D areas are relatively small and often fragmented. Through discussions with ERDA, DOE, and laboratory officials and our analysis of documents they provided, we identified

five major factors which have contributed to the laboratories' small and fragmented nonnuclear energy RD&D roles:

- The roles of the multiprogram laboratories were determined on a piecemeal basis;
- ERDA and DOE emphasized using private industry for developing nonnuclear technologies;
- The incompatibility of the laboratories' perceived roles with the Administration's increased emphasis on the near- and mid-term energy technologies;
- ERDA and DOE were reluctant to expand the multiprogram laboratories; and
- Other in-house research facilities competed for non-nuclear energy RD&D work.

The roles of the multiprogram laboratories were determined on a piecemeal basis

Each laboratory's activities were largely decided during the annual budget process. In this process (1) each laboratory proposed to carry out specific tasks, (2) individual ERDA headquarters managers selected proposals for which they requested funding, and (3) ERDA, the Office of Management and Budget, and ultimately the Congress approved funding of the tasks to be carried out during the annual budgeting process. This "bottom-up" approach has led to the piecemeal assignment of nonnuclear energy RD&D tasks to the laboratories.

We interviewed officials in 12 divisions in the ERDA headquarters' Offices of Fossil Energy; Solar, Geothermal, and Advanced Energy Systems; and Conservation, to determine how they selected projects and performing organizations to accomplish their objectives. Basically, headquarters program managers evaluated the tasks proposed by various performing organizations by (1) determining if the tasks were designed to meet program objectives, (2) evaluating the merit of proposed tasks, and (3) assigning relative priorities to the tasks. However, we noted that the source of inputs and criteria for evaluating tasks varied among divisions and even among managers within each division.

In evaluating tasks, headquarters program managers considered information available to them from a number of sources such as outside consultants, support contractors, technical review panels, and personal contacts. The extent to which program managers chose to use such sources varied with each

manager. For example, one program manager relied primarily on ERDA laboratories and universities, whereas another program manager relied on special studies, industry contracts, and headquarters staff. Still another program manager used an ad hoc project evaluation committee, comprised of Federal agency officials, and analyses by a support contractor. ERDA officials said that the sources of inputs vary among project managers because each program area has its unique sources of technical knowledge.

Each of the program managers we interviewed said that they select only those performing organizations which have the technical expertise and competence required to do the work needed. However, these managers often set their own informal criteria and established priorities on the basis of undocumented technical judgments.

Only 2 of the 12 divisions we reviewed--the Division of Building and Community Systems and the Division of Industrial Energy Conservation in the Office of Conservation (the Office of Conservation and Solar Applications under DOE)--had a formalized approach for selecting projects. These two divisions jointly developed a computerized evaluation system which provided a quantitative screening to eliminate projects that (1) industry should undertake, (2) have a low probability of commercial success, and (3) fail to provide an adequate benefit per dollar invested by the Federal Government. The computer then ranked each project using a scoring model which considered such factors as energy savings, environmental impact, secondary economic and social impacts, and the probability of success. This sort of use of a systematic, quantifiable assessment may usefully serve as an example of the kind of uniform approach needed for assigning work to each of the laboratories.

In the absence of the systematic definition and integration of the multiprogram laboratories' roles into DOE's RD&D efforts through the new program, planning, and budgeting system, decisions as to the tasks the laboratories are to undertake will continue to be made during the annual budget process on a task-by-task basis. We are, therefore, concerned that, in the absence of clearly defined, uniform criteria, the piecemeal assignment of nonnuclear energy RD&D tasks to the laboratories may continue under DOE.

Emphasis on use of industry for nonnuclear energy RD&D

ERDA's and DOE's approach to bringing into use new technologies for energy conservation and for expanding domestic energy production has been to press for the highest possible

levels of industry cooperation and involvement in the development of all technologies, including nonnuclear. They chose this approach to accelerate the development of new technologies, make maximum use of industry's expertise, and speed the process of bringing technologies into use.

We generally agree with this approach and its objectives. Because industry has been involved in the development of non-nuclear technologies for many years, they have developed capabilities which should not be ignored in working toward solving the Nation's energy problems. As demonstrated in the commercialization of nuclear reactors, industry involvement in RD&D also facilitates the transfer of new technologies into salable products in the marketplace.

We found, however, that this approach has placed a heavy burden on headquarters management personnel who are charged with the overall mission coordination and direction, including oversight responsibility for work being carried out by industry. As a result, we noted that ERDA headquarters had obtained large amounts of management support from the laboratories, as well as from industry itself.

In two previous reports 1/, we noted that in nonnuclear energy RD&D, ERDA was relying on industry for some program support services such as reviewing and revising budget justifications, program planning, evaluating proposals, technical studies, and the technical monitoring of contracts. ERDA officials' rationale for obtaining this support was that they had to carry out the expanded nonnuclear energy RD&D programs in short time frames with essentially the same staff as that transferred from other agencies at the time ERDA was established. As we previously reported, we believe that the effect of an agency contracting out its basic functions for the planning and management of its programs dilutes the agency's ability to retain essential control over the conduct of its programs and to assure the Congress that its programs are being carried out in an efficient and economical manner.

1/"Comments on ERDA's Contract with TRW, Incorporated for Planning and Analysis Services," EMD-76-11, September 21, 1976.

"Comments on Certain Management and Funding Aspects of Selected Nonnuclear Energy Research, Development, and Demonstration Subprograms," EMD-77-24, February 25, 1977.

Incompatibility of laboratories' perceived roles with Administration's increased emphasis on near- or mid-term technologies

On April 29, 1977, the White House released its National Energy Plan which combines legislative, administrative, and budgetary proposals aimed at solving the Nation's energy problems. The plan sets out seven national energy goals and outlines a broad program designed to achieve these goals by 1985. It calls for measures ranging from both mandatory and voluntary conservation actions to expanded research on nonconventional energy sources, such as solar and geothermal energy, fusion, and municipal solid waste. In regard to this expanded research, the plan noted that the Administration was reorienting its RD&D priorities and proposing to increase funding for energy conservation and certain other solar and geothermal resources with near- and mid-term potential.

In line with this reordering of priorities, the President made major revisions to ERDA's fiscal year 1978 budget request. Increased authority of \$247 million was requested for near-term efforts on conservation, fossil, and solar heating and cooling applications. This increased funding was provided primarily from reductions in long-term programs, such as the nuclear breeder, fusion, and solar electric applications. As a result, the laboratories are facing funding reductions in some of their current long-term, high-risk RD&D efforts.

Officials at each of the multiprogram laboratories believed the laboratories should be used in long-term, high-risk RD&D and that they should not compete with industry or universities. They believed industry should perform the short-term RD&D projects and that universities should perform the small scale basic and applied research projects.

Officials at the Los Alamos and Oak Ridge laboratories expressed their concern that the multiprogram laboratories were not being optimally used in nonnuclear energy RD&D because they have not been able to undertake more long-term nonnuclear energy RD&D projects. These officials said that nonnuclear energy RD&D program managers at headquarters were not familiar with the capabilities and potential of the multiprogram laboratories. Officials at Los Alamos pointed out that as a result the laboratories are involved in solving short-range nonnuclear energy RD&D problems that could be done by industry. These officials believed that nonnuclear energy RD&D program managers should obtain a better understanding of the laboratories' capabilities and potential and assign them missions in appropriate areas. With mission assignments, they believed that DOE and the laboratories could better coordinate with industry and

universities to make certain that projects are assigned to the best suited facilities.

Officials at the other six multiprogram laboratories acknowledged that they had relatively small efforts in nonnuclear energy RD&D, but were generally satisfied with their roles because such roles are relatively new for them and they expected their nonnuclear energy roles to expand as they gain additional expertise and the programs evolve.

Thus, the Administration's increased emphasis on near- and mid-term technologies has been a limiting factor because the laboratories have preferred to place their efforts on long-term, high-risk projects instead of considering their roles to be in areas where DOE, and formerly ERDA, needed their capabilities.

Reluctance to expand multiprogram laboratories

Although ERDA believed that the laboratories should play a role in the development of nonnuclear energy RD&D, ERDA and DOE have been concerned that an extensive expansion of the laboratories' facilities and staffing would reduce the laboratories' effectiveness in carrying out RD&D. Their specific concerns have been that (1) the weapons laboratories may be growing too much in the nonnuclear area and therefore reduce their effectiveness in weapons development and (2) the nonweapons laboratories would grow beyond future budget capabilities to support them. As a result of these concerns, ERDA established criteria for assigning nonweapons work to the weapons laboratories, which in our opinion, have limited nonnuclear energy RD&D work too much. DOE has adopted similar criteria for assigning work to the weapons laboratories and is developing procedures and controls which may similarly limit new assignments to the other multiprogram laboratories.

ERDA's criteria was established in response to a recommendation made by a study group, composed of senior ERDA and DOD representatives, on the ERDA weapons complex which included three multiprogram weapons laboratories--Los Alamos, Lawrence Livermore, and Sandia. ERDA conducted this study in collaboration with DOD in response to Section 307(b) of the Energy Reorganization Act of 1974, which required a thorough review of the desirability and feasibility of transferring ERDA's weapons development and production activities to DOD or other Federal agencies.

The study group completed its study in January 1976 and recommended that the weapons complex remain in ERDA and that the situation be reconsidered in 2 to 3 years when ERDA gained

more experience in dealing with the weapons complex. The primary factor underlying this recommendation was that by remaining in ERDA, the nuclear weapons complex including the weapons laboratories, would be readily available to undertake energy RD&D missions for which they are uniquely qualified. However, because nuclear weapons efforts, for security reasons, must be largely accomplished within the weapons complex while energy RD&D can be accomplished elsewhere, it was further recommended that steps be taken to preserve the ability to accomplish the primary mission of the weapons complex--weapons research, design, development, production, and storage.

As a result, ERDA's Assistant Administrator for National Security, with input from each of the other ERDA Assistant Administrators, developed the following criteria for accepting or rejecting nonweapons work.

- Work should be limited to work that can be accomplished in the laboratories.
- Work should be limited to that which requires the laboratories' unique capabilities and cannot be accomplished elsewhere.
- Nonweapons work is not to unduly hamper weapons work.
- Nonweapons work undertaken should complement weapons work.
- The capability should be retained to transfer resources from nonweapons to weapons work if necessary.

Although the criteria do not specifically mention non-nuclear energy RD&D, ERDA's Assistant Administrator for National Security told us that they would primarily affect nonnuclear energy RD&D because it generally does not complement weapons work. However, he said that no ongoing nonnuclear energy RD&D projects had been reassigned or terminated as a result of their criteria, but that the weapons laboratories' future nonnuclear energy RD&D work would be limited. For example, ERDA's Office of National Security was monitoring Sandia's involvement in the 10 megawatt solar central receiver proof-of-concept pilot plant project. The central receiver system is characterized by a large number of mirrors, called heliostats, which reflect the solar energy to a single receiver. At the receiver, the solar energy is collected and converted to thermal energy which is subsequently converted to electricity. According to the Assistant Administrator for National Security, responsibility for this project may be considered for transfer to SERI.

In the fall of 1976, at the request of the Office of National Security, each of the weapons laboratories projected their future workload requirements for fiscal years 1977 through 1982. According to the Assistant Administrator for National Security, the three laboratories' projected workloads, if permitted, would have resulted in a growth in staffing levels from their total of about 17,000 to about 19,500, or an increase of about 2,500 people. In December 1976 he believed that an increase of such magnitude would impair the efficiency of the laboratories. Hence, at that time he stated that only 50 to 75 percent of the projected increases would be permitted, with about 40 percent of this increase for weapons work. He pointed out, however, that no ceiling had been established for the amount of nonweapons work and the laboratory directors have the flexibility to plan their work, subject to the constraints of the limiting criteria.

DOE officials subsequently pointed out that in 1977 they made a review to determine a realistic growth rate for the weapons laboratories and found that the 2,500 growth figure was realistic. Thus, the agreed upon growth for the three weapons laboratories for the fiscal year 1977 to 1982 time frame was set at 2,473 staff. These officials further pointed out that the criteria for assigning work to the weapons laboratories was implemented to ensure that energy program managers have access to these laboratories for energy-related work. Although these officials acknowledged that it could be presumed that the assignment of the weapons laboratories to the Assistant Secretary for Defense Programs would likely result in these laboratories making limited contributions to energy programs, specifically nonnuclear energy programs, they pointed out that experience under ERDA and DOE has not shown this to be the case. Instead, they said that no restrictions have been made to limit the availability of these laboratories to energy program sponsors and that ERDA and DOE policy and work assignment oversight procedures are based on providing the most effective use of laboratory capabilities in both the weapons and energy areas.

As ERDA's and DOE's decision to allow the weapons laboratories to grow at about the same rate as initially proposed by the laboratories in the fall of 1976 indicates, an increase of the laboratories' workload and staffing would not impair their ability to effectively carry out their work, if properly managed. While the weapons laboratories' experience under the assignment criteria may not have resulted in reduced levels of nonweapons work, we believe that this criteria has contributed to the multitude of diverse nonnuclear energy RD&D tasks being carried out by these laboratories. DOE's interim management directive on the use of the weapons laboratories and facilities for nonweapons activities states, in part:

"It is the policy of the DOE that the paramount mission of the weapon complex is the successful execution of the weapon program, and such steps will be taken as are necessary to preserve this principle. The utilization of the capabilities of the weapon complex in support of DOE's non-weapon responsibilities or other programs of national interest is encouraged but limited to the extent that such utilization does not unduly interfere with the nuclear weapon program."

We noted that, in carrying out this policy, ERDA and DOE have allowed the levels of nonweapons work to increase, but these laboratories have only been assigned narrowly-scoped new tasks in the nonnuclear energy programs. For example, in Los Alamos' report, "Long Range Projections 1977 - 1983," revised as of December 16, 1977, the laboratory notes that "* * * it appears to be entering a period of consolidation and expected accomplishment within R&D areas already authorized." Los Alamos further notes, however, that a steady inflow of new projects, coupled to a closing out of others that have run their course, is clearly recognized as essential to the preservation of its vitality as well as that of any other institution.

Similarly, Lawrence Livermore noted in its institutional plan, dated November 1977, that the laboratory "* * * believes it can make important contributions to the development of advanced fossil energy technologies, solar energy, and nuclear energy well beyond the relatively small programs (tasks) it is now conducting in these areas." In this regard, the plan noted that the laboratory is working with DOE to overcome past barriers to the laboratory's effective use in energy technology development, such as a lack of delegation of authority to the laboratory for flexible execution of assigned work within DOE-defined goals.

Sandia's report, "Sandia Laboratories 5-Year Projections Fiscal Years 1978 - 1983," July 1977, similarly indicated that the laboratory's future workload had been restricted in respect to new starts. The report states that while projected overall growth is "deliberately restrained," the laboratory's experience has shown that its staffing practices provide the flexibility to meet expanded program requirements without sacrificing staff quality. The report also notes that energy program activity is expected to gradually increase between fiscal years 1978 and 1983--a staffing increase of 20 percent and a constant dollar increase of about 35 percent; but that this increase reflects a maturing of its ongoing efforts toward engineering development and demonstration.

In commenting on this matter, officials at the three weapons laboratories agreed that the assignment criteria had not significantly affected their ongoing work, but told us that it limits their new starts in nonnuclear energy RD&D.

It appears to us that the procedures for assigning non-weapons tasks to the weapons laboratories have resulted in limiting such tasks principally to those areas in which they have had ongoing work. DOE has expressed a reluctance to expand the laboratories and has proposed to develop and implement similar procedures for assigning work to the other multiprogram laboratories. Hence, we are concerned that the multiprogram nature of these laboratories will be impaired as their ongoing efforts are completed.

Competition from other in-house research facilities

Another factor limiting the multiprogram laboratories' activities in nonnuclear energy RD&D is competition from research facilities, such as SERI in solar energy and the five energy research centers in fossil energy. The existence and possible expansion of such facilities have been considered by ERDA and DOE headquarters program managers in assigning tasks to the laboratories. Headquarters managers have been reluctant to expand the multiprogram laboratories' capabilities in solar RD&D because responsibilities for such work may eventually be transferred to SERI, and in fossil energy such work might be more appropriate for the energy research centers which are dedicated to fossil energy work.

Competition from SERI

SERI's creation was authorized pursuant to the Solar Energy Research, Development, and Demonstration Act of 1974 (Public Law 93-473, dated October 26, 1974). The act called for a facility to be available to DOE (and formerly ERDA) to carry out solar energy research, development, and related functions. During its efforts to establish SERI, ERDA decided that SERI would consist of a national facility located--at least initially--at Golden, Colorado, and four regional components comprising the regional SERI network. Although the national SERI has been operating since July 1977, its specific roles, functions, and responsibilities still have not been determined. In addition, DOE has planning studies underway to determine the appropriate roles and organizational structures for each component of the regional network.

According to DOE officials, however, they expect the roles of SERI and the network to cover a broad spectrum of the Federal solar energy efforts, including research, development, and

commercialization. These officials pointed out that they, therefore, have had to give consideration to the anticipated eventual role of SERI and the regional network in making decisions relative to assigning additional solar energy work to the multiprogram laboratories. These officials indicated that during the past year, for example, no new major solar assignments have been made to these laboratories and their additional efforts have been comprised essentially of small, narrowly defined tasks. In addition, one DOE official pointed out that some consideration is being given also to transferring certain portions of the multiprogram laboratories' solar work to SERI and/or the regional SERI network.

We agree that in assigning tasks to the laboratories, the availability of other research entities must be considered. The new SERI and the regional SERI network may eventually have extensive solar energy RD&D and commercialization responsibilities. However, certain multiprogram laboratories, such as Sandia, have capabilities and facilities that can and have been used toward finding solutions to solar energy RD&D problems. We similarly pointed this out in a report to the Chairman, Subcommittee on Advanced Energy Technologies and Energy Conservation Research, Development and Demonstration, House Committee on Science and Technology (EMD-77-67, September 9, 1977). In that report, we noted that the continued use of certain laboratories for solar energy RD&D would capitalize on the availability of experienced researchers and existing computer capabilities, hardware, and management structure. The following section discusses the relationship between SERI and the laboratories.

To ensure that the existing capabilities and facilities of multiprogram laboratories are used and do not duplicate SERI's efforts, their solar energy RD&D roles must be clearly delineated, interfaced, and integrated with the eventual roles of SERI and its regions. Alternatively, SERI could be used in areas where the laboratories do not have RD&D capabilities and as a focal point for all solar work.

Competition from the energy research centers

DOE inherited five energy research centers from ERDA. These centers are Government-owned and -operated facilities which generally conduct in-house fossil energy RD&D and report directly to the Assistant Secretary for Energy Technology. Administrative support is provided by selected field operations offices. Although the size of the five energy research centers has remained constant at about 800 Federal employees in total, the magnitude of their operations has increased rapidly. The budgets for all five centers totaled about \$8 million in 1974

and rose to about \$47 million in fiscal year 1977 to support the management or monitoring of extensive projects, often with matching funds from industry.

The five energy research centers and their general areas of specialization are:

- Morgantown Energy Research Center--gas shale and gas.
- Pittsburgh Energy Research Center--coal.
- Bartlesville Energy Research Center--petroleum.
- Grand Forks Energy Research Center--coal (lignite).
- Laramie Energy Research Center--oil shale and petroleum.

In the spring of 1977, we discussed the interface between the multiprogram laboratories and the energy research centers with officials at the Pittsburgh and Laramie Energy Research Centers. These officials told us that the energy research centers have been carrying out extensive amounts of fossil energy work because they have the necessary background and capabilities for such work. They said that they have been interfacing with universities and industry through seminars, workshops, and special assistance to fossil energy technology users; by contracting for RD&D support work; and by participating in joint Government/industry projects. However, they said that they have had little interface with the multiprogram laboratories because ERDA's headquarters program managers have closely managed fossil energy work and dealt directly with the laboratories.

Energy research center officials told us that the multiprogram laboratories are carrying out fossil energy tasks because (1) the laboratories have unique capabilities developed in their nuclear RD&D efforts which can be applied to certain fossil energy research areas such as environmental R&D and basic catalysis work and (2) the energy research centers staffing levels had not been increased so their work efforts had been generally limited to those fossil energy RD&D areas in which they already had work underway.

These officials said that the multiprogram laboratories have often duplicated their work, and the work of universities and industry. They explained that before the multiprogram laboratories' unique capabilities can be applied to fossil energy RD&D, those laboratories must obtain a working knowledge of the fossil energy technology and, as a result, often carry out tasks to develop information that is already known or is already being developed by the energy research centers, universities, or industry.

For example, officials at Laramie told us that the multiprogram laboratories had developed a knowledge and capability for fracturing in their nuclear work which could be applied to in situ oil shale technologies, but were not familiar with oil shale technologies. Therefore, according to these officials, the laboratories undertook tasks to develop information on what was already known or being developed by certain universities, industrial entities, and the Laramie Energy Research Center.

To remedy this situation, the Director, Laramie Energy Research Center, told us that his center should be delegated authority to manage oil shale projects and use those universities, industrial entities, and multiprogram laboratories which have the capabilities needed to carry out specific needed tasks. In this way, he said that his center could serve as a central control center to integrate information, solve problems, and supervise and monitor contract work. The Director pointed out that this application of a matrix management technique, whereby the research center's direct research efforts are extended to efforts by outside contractors, would effectively use existing staff members without unnecessarily increasing the number of Government employees.

In line with the Director, Laramie Energy Research Center's comments, DOE has established a policy for the energy research centers to amplify their work by contracting work to industry, universities, and other Government facilities. In carrying out this policy, the energy research centers have been delegated project management responsibilities and have redirected their staff efforts to a matrix-type organization for carrying out those responsibilities. Consequently, with contracting support from field operations offices, the energy research centers have been increasing the amount of work they are contracting out.

Hence, one means of effectively using the multiprogram laboratories' capabilities may be to delineate supporting roles for them in areas where other Government facilities have broader expertise. Entities such as SERI or the energy research centers could be assigned broad missions and use the specific capabilities of the multiprogram laboratories, as well as universities and industry, to help carry out those missions. In some areas where a laboratory has extensive expertise, such as in certain solar areas, the laboratories could be assigned relatively large responsibilities including those for project management. In other areas, such as in situ oil shale, a laboratory could be assigned relatively narrow tasks which draw upon its specific capabilities. Entities such as SERI and the energy research centers could then be the focal point responsible

for ensuring that all work is properly coordinated and interfaced among universities, industry, and Government facilities.

DOE'S ORGANIZATIONAL ALINEMENT OF
THE LABORATORIES IS NOT CONDUCTIVE
TO THEIR USE IN NONNUCLEAR
ENERGY RD&D

In addition to those factors that have limited the roles of the multiprogram laboratories in nonnuclear energy RD&D, we noted that DOE's alinement of five laboratories to offices responsible for specific programmatic areas may further limit such nonnuclear roles. In recognizing the laboratories' fragmented nonnuclear energy RD&D efforts under ERDA, DOE alined five of the multiprogram laboratories to the offices responsible for programs in their principal areas of effort--the three weapons laboratories were alined to the Office of Defense Programs and the two laboratories principally in fundamental research were alined to the Office of Energy Research. The other three laboratories have large efforts in more than one program and report to the Office of the Under Secretary.

According to a member of DOE's activation task force, which helped formulate DOE's field organization, the laboratories were alined to program offices responsible for their principal areas of effort to provide a more focused approach to their efforts. According to this official, the task force believed this would restrict the laboratories' involvement in other areas and the laboratories would eventually become specialized laboratories in their principal areas of effort. This official told us, however, that the ultimate areas in which the laboratories conduct their activities will be determined through negotiations between the Assistant Secretaries having programmatic RD&D responsibilities and the office to which the laboratories are alined.

An official within DOE's Office of Energy Research, which is responsible for overseeing the use of the multiprogram laboratories, told us that he did not anticipate any change in the manner in which the laboratories will be used. This official believed that agreements will be reached similar to ERDA's criteria on assigning work to the weapons laboratories. Under this criteria the laboratories may conduct work in any area, but work in their principal areas of effort are given priority. He pointed out that DOE's Field and Laboratory Coordination Council has assumed the former role of ERDA's Office of Field Operations. Thus, the Council is to establish policy and coordinate activities with respect to DOE's R&D field installations, including the multiprogram laboratories. This Council is chaired by the Under Secretary and composed of the Assistant

Secretaries, the Director of Energy Research, the Administrator of the Energy Information Administration, the Director of Administration, the Controller, and the Director of Procurement and Contracts Management.

In October 1977 officials at each of the multiprogram laboratories told us they were uncertain of the impact of DOE's organization on their roles. Officials at the fundamental research laboratories--Brookhaven and Lawrence Berkeley--were generally pleased with their alinement to the Office of Energy Research. However, officials at the three laboratories not alined to a particular program office--Argonne, Oak Ridge, and Pacific Northwest--were concerned that they would be the only laboratories without a sponsor and their workloads may ultimately suffer. Officials at the weapons laboratories, particularly Los Alamos, were concerned that their alinement to the weapons programs would further restrict their efforts in energy programs. The laboratory director at Los Alamos explained that they can neither reasonably expect the Assistant Secretary for Defense Programs to provide funds for energy-related supporting research nor to lobby for such support from other Assistant Secretaries. This official believed that this weakening of their research base would also weaken the overall quality of their weapons-related activities because a diversity of R&D efforts strengthens the overall quality of work in all RD&D programs.

We agree that a diversity of R&D efforts is needed to maintain the multiprogram laboratories' special capabilities. In our opinion, the cross fertilization of research efforts in different fields enhances their capabilities to perceive new technological problems and respond to them rapidly and flexibly. However, we believe that the alinement of five multiprogram laboratories to offices responsible for specific areas of research would tend to erode the capabilities of those laboratories in other areas, such as nonnuclear energy RD&D. When priority is given to certain program efforts and limited in others, such as in the criteria for assigning work to the weapons laboratories, a laboratory's efforts for program offices other than that to which it is assigned will be subject to that laboratory's availability. Thus, tasks would tend to be assigned on a piecemeal basis and continue to focus on fragmented portions of technologies.

CHAPTER 4

ISSUES SURROUNDING THE DEFINITION OF NONNUCLEAR ENERGY ROLES FOR THE MULTIPROGRAM LABORATORIES

Many of the factors limiting the roles of the multiprogram laboratories in nonnuclear energy RD&D would be negated if such roles were clearly defined, while other factors indicate a need for close interface between the laboratories and other research entities. Hence, we believe that the multiprogram laboratories' roles should be defined in a manner that would enhance the interface among all research entities involved in nonnuclear energy RD&D.

The multiprogram laboratories' nonnuclear energy RD&D efforts represent only a fraction of the Federal efforts in this area. For example, from July 1, 1975, through March 31, 1977, these laboratories accounted for about one-sixth of ERDA's total outlays for nonnuclear energy RD&D as shown in table 9.

Table 9

ERDA's Nonnuclear Energy RD&D Funding Outlays by Type of Organization from July 1, 1975, through March 31, 1977

<u>Type of organization</u>	<u>Outlays</u> <u>(note a)</u> <u>(millions)</u>	<u>Percent</u> <u>of total</u>
ERDA:		
Headquarters	\$ 2.8	0.3
Field offices	3.3	0.4
Multiprogram laboratories	142.9	16.6
Specialized laboratories	65.3	7.6
Nuclear materials and weapons production facilities	<u>1.5</u>	<u>0.2</u>
Subtotal	<u>215.8</u>	<u>25.1</u>
Other Federal agencies	86.3	10.0
Private industry	471.8	54.7
Universities	54.0	6.3
Nonprofit institutions	22.8	2.6
Other entities	<u>10.9</u>	<u>1.3</u>
Total	<u>\$861.6</u>	<u>100.0</u>

a/Includes outlays for plant and capital equipment.

Most of the work carried out by universities and nonprofit institutions was in the research phase of RD&D. These entities received about 40 percent of ERDA's funding for work in this phase which includes basic and applied research in the environmental, informational, and engineering sciences. Funds received by Government entities, including the multiprogram laboratories and energy research centers, were for work in all RD&D phases. According to the Mitre Corporation, these entities received about 58 percent of ERDA's funds for work in the research phase, 49 percent in the technology development phase, 28 percent in the engineering development phase, and 6 percent in the demonstration phase. Most of the rest of the funding in technology development, engineering development, and demonstration phases was received directly by industry from ERDA.

While universities generally used funds awarded to them for in-house work, the multiprogram laboratories and industrial contractors often used a large portion of the funds for subcontracts to other entities. According to Mitre Corporation, the multiprogram laboratories used about 40 percent of the funds for subcontracts, primarily to industry for materials, supplies and equipment, and other services--with only small amounts subcontracted for RD&D. Industrial contractors similarly used large amounts of funds for subcontracts to other industrial entities.

Thus, while the multiprogram laboratories carry out work in the same RD&D phases as industry, universities, and other research entities, the laboratories appear to have had little interface with these entities in carrying out their respective RD&D tasks.

To determine how increased interface among research entities can be achieved, we examined five principal issues which need to be considered in defining the multiprogram laboratories' roles:

- Should the laboratories have significant missions in nonnuclear energy RD&D?
- How extensive should the laboratories' roles be in basic research, technology development, engineering development, and demonstration?
- Should the laboratories have the authority to carry out project management responsibilities?
- Should the laboratories be used for funneling money to industry?

--How extensively should the laboratories be involved in setting policy, plans, and priorities?

SHOULD THE LABORATORIES HAVE SIGNIFICANT MISSIONS IN NON-NUCLEAR ENERGY RD&D?

The general opinion of ERDA, DOE, laboratory, industry, and university officials involved in energy RD&D is that the multiprogram laboratories have capabilities that should be applied to nonnuclear energy RD&D. Although these officials had varying opinions as to what that role should be, they generally agreed that the roles of the laboratories should be delineated through mission assignments.

Laboratory officials believed the laboratories should be assigned major missions and have considerable discretion as to the approaches they would take to accomplish those missions. These officials pointed out that they generally have had such discretion in their basic research, nuclear weapons, and nuclear energy efforts with considerable success.

Industry officials believed the multiprogram laboratories needed missions assigned to focus their approach to nonnuclear energy RD&D. They further believed that such missions should be earned and only assigned if the laboratories had the needed capabilities. They were concerned that the multiprogram laboratories were getting into everything and unfairly competing with them. They pointed out that the laboratories have close relationships with headquarters program managers and have an advantage in obtaining work. They also believed that the laboratories were taking a "shotgun" approach to nonnuclear energy RD&D and, in some cases, were duplicating industry efforts. Although some industry officials cited cases of duplication, our review of such cases did not substantiate their claims. In the cases cited, we found that the industry officials had a misunderstanding of the scope and nature of the laboratories' efforts.

University officials also believed that the multiprogram laboratories should be assigned missions to provide a more focused approach to nonnuclear energy RD&D. Some of these officials cited the success of NASA's efforts and suggested that missions be assigned in a manner similar to NASA's space flight model.

Under the NASA space flight model, in-house research facilities are assigned specific missions. Within a mission, the research facility is delegated the authority to carry out management responsibilities and is provided funds needed to carry out projects. The research facilities subcontract up to

90 percent of the project funds for work carried out by universities and industry. These facilities retain about 10 percent of the project funds for in-house work needed to maintain technical capabilities or to do work that cannot be accomplished elsewhere.

Under the NASA project management concept, NASA assumes that no single company, regardless of its excellence, has all the skills and experience required for the execution of a major project. Therefore, although it relies predominantly on industry to build, integrate, and test hardware, NASA uses its in-house management and technical capabilities at its research facilities to monitor and work with its contractors. When problems are confronted by a contractor, the research facilities, in carrying out project management responsibilities, can seek assistance in overcoming these problems either from in-house capability or from other sources with the needed technical competence.

This model has been successfully used in the NASA space flight program. However, there are at least two major differences between the nature of products of the space flight program and those of nonnuclear energy RD&D programs. First, the NASA space flight model was established to develop products where the Government was the ultimate customer, whereas in nonnuclear energy RD&D, industry and ultimately the general public are the customers. Second, space flight program products were unique products which had no commercial competition and limited socioeconomic constraints. Nonnuclear energy technologies, on the other hand, must compete in the marketplace with other energy sources and involve a wide range of social, economic, environmental, political, and legal constraints. Thus, because of the differences in the nature of the products, this model may not be the best mode for managing nonnuclear energy RD&D.

ERDA and DOE officials also believed that nonnuclear energy RD&D missions should be assigned to the multiprogram laboratories. In line with ERDA's Field and Laboratory Utilization Study Group's recommendation that such missions be assigned to the laboratories, ERDA's Office of the Assistant Administrator for Field Operations took steps designed to have such missions assigned. This Office had obtained from each laboratory an extensive list of proposed mission areas. However, we noted that most of these proposed nonnuclear energy RD&D missions were for relatively narrow areas and appeared to represent their proposed projects or tasks already included in each laboratory's existing plans; that is, little new or innovative broad mission initiatives were produced by this effort.

An official within the Office of the Assistant Administrator for Field Operations (now within DOE's Office of Energy

Research) told us that because the laboratories had proposed numerous tasks and not missions, his office's approach was to have each of the cognizant headquarters program offices review the proposed tasks within its respective program areas to determine which areas would be appropriate laboratory missions. According to this official, each area a program office deems to be appropriate as a laboratory mission would be assigned to that laboratory. This official said these missions had not yet been assigned as of January 1978.

We agree that nonnuclear energy RD&D missions should be assigned to the multiprogram laboratories. Although DOE is taking steps to assign missions to the laboratories, we believe that to provide the flexibility needed to optimally use their capabilities, the nonnuclear energy RD&D missions should be clearly defined such as they were in their historical mission roles in nuclear energy and weapons RD&D. Such missions could be entire technologies such as solar photovoltaic energy and superconducting transmission lines or support type functions such as energy modeling. In assigning missions, steps must be taken to ensure that the laboratories have the resources and capability to carry them out, and that they are integrated into DOE's overall RD&D efforts. Once missions are assigned, to ensure that nonmission work does not interfere with the accomplishment of laboratory missions, priority should be given to the work in mission areas.

Such a framework for mission assignments would, in effect, establish boundaries within which a laboratory would conduct and contract out RD&D work. All such work, of course, would continue to be subject to the overall direction and approval of headquarters program managers. Because its work would be essentially limited to assigned missions, it is essential to select missions that would optimally use each laboratory's potential to help carry out DOE's overall energy RD&D missions and provide headquarters with the needed in-house capability.

DOE officials told us that on the basis of in-depth studies, such as the FLU study, and institutional plans, they have a good understanding of the capabilities of the laboratories for carrying out work in each energy technology. Thus, they said that the problem is not in knowing the capabilities of the laboratories, but there are a host of practical problems which arise in making mission assignments. For example, these officials said that they must decide (1) which technology base areas should be assigned to each laboratory, (2) how large each assignment should be, and (3) what levels of duplication, if any, are desirable.

Accordingly, we believe that a comprehensive study of the ramifications of assigning each multiprogram laboratory

missions needs to be made. Such ramifications must be weighed in light of each laboratory's potential for contributing solutions to the problems facing each of the nonnuclear energy technologies. On the basis of these studies and its programmatic priorities, DOE should assign laboratories appropriate missions in nonnuclear energy RD&D. In assigning such missions, care must be taken to ensure that the laboratories' efforts are properly interfaced with other research entities' efforts in those missions.

HOW EXTENSIVE SHOULD THE LABORATORIES' ROLES BE IN BASIC RESEARCH, TECHNOLOGY DEVELOPMENT, ENGINEERING DEVELOPMENT AND DEMONSTRATION?

The officials in energy RD&D that we contacted generally agreed with ERDA's informal criteria for multiprogram laboratories' participation in energy RD&D. As discussed in chapter 3, these criteria generally state that the multiprogram laboratories' role should decrease and industry's role increase as the technology progresses through the various phases of RD&D leading to commercialization. These criteria also state that universities are to have a major role in basic research, but their involvement is to be phased out during technology development.

Laboratory officials believed that the multiprogram laboratories' efforts should be in long-term, high-risk areas and that they should not compete with industry or universities. They said that the laboratories must perform basic research to obtain new scientific and technical data in support of applied research. These officials pointed out that laboratories have unique capital intensive equipment which is not considered appropriate for university campuses. Although the laboratories are the primary users of this equipment, they said that universities often use the equipment under formal agreements. Because industry generally performs RD&D for the profit motive, the officials said industry lacks the incentive to perform large-scale, basic research.

In the technology development phase, laboratory officials believed the laboratories should have a major role up to the determination of technical feasibility. They said that they would not be competing with universities because university laboratories are largely staffed with students and lack the continuity to carry out long-term efforts. Regarding industry, they said that because of the profit motive, industry would not have the incentive to perform this long-term, high-risk work.

In the engineering Development phase, laboratory officials believed the laboratories primarily should provide technical assistance to industry and help monitor and evaluate the progress of work being conducted for DOE. They pointed out that this technical assistance was an important means for transferring technologies to industry. In some cases, however, they said that industrial entities capable of developing that technology may not want to develop a technology because of conflicts of interest. For example, one official felt that the automotive industry may not have sufficiently strong motivation to develop new storage battery systems because of their vested interest in current systems. In such cases, he said that the laboratories should carry out the work in the national interest.

In the demonstration phase, laboratory officials said their role should be similar to that in the engineering phase, but less technical advice would have to be provided because of industry's previous involvement in the engineering phase.

Although industry officials generally agreed that the laboratories' roles in the various RD&D phases should be along the lines of the ERDA criteria, they were generally suspicious of how this concept is implemented in practice. These officials contended that the laboratories try to extend their roles into the engineering development phase and that they tend to pursue their pet projects even though those projects sometimes have little potential for commercial application.

Some industry officials said that industry should carry out large-scale technology development tasks that are targeted for specific commercial applications because it is essential for those conducting this type of research to have experience in and knowledge of the commercial market. They explained that the laboratories tend to develop a product and then try to fit it into the marketplace, while industry would first determine the market's need and then develop a product to fit that need.

Some industry and university officials said that the laboratories should operate in the NASA space flight mode and have project management responsibilities for all projects, but have industry and universities carry out the work.

University officials generally agreed with the informal criteria, but believed that universities should have a larger role in basic research. These officials acknowledged that the laboratories have to conduct a certain amount of basic research to retain their capabilities for applied research, but were suspicious that the laboratories' close relationships with ERDA and DOE had enabled them to extend their roles. For example, one official said that because of their close relationships,

the laboratories are able to obtain constant levels of funding for basic research, and the universities compete among themselves for the balance of DOE's basic research funds. Therefore, he said that when DOE's basic research funding is reduced, universities end up with little or no funds.

Several industry and university officials believed that all energy RD&D roles and tasks should be earned on a best-performer basis. However, they expressed concern that it would not be possible to compete with the laboratories on a fair basis because the laboratories have close relationships with DOE. Therefore, many of these officials suggested that the laboratories' roles should be limited to those areas that the private sector cannot or does not want to do.

Some other industry and university officials suggested that all energy RD&D tasks and projects be awarded on a basis similar to the management model used in the National Science Foundation/Research Applied to National Needs (NSF/RANN) program. The NSF/RANN model was used primarily for providing funds to research entities for carrying out basic and applied research. NSF does not have in-house research facilities. Under this model, research entities, primarily universities and nonprofit institutions, usually submitted proposals for the projects they wanted to undertake. With the assistance of peer review and ad hoc panels, NSF evaluated and selected the proposed tasks or projects to be undertaken. During fiscal year 1977, about \$68 million was provided to such research entities for carrying out projects under the NSF/RANN program.

This model appears to us not suitable for application to nonnuclear energy RD&D. It is a bottom-up approach which relies on others to conceive ideas, determine priorities, and do the work. If such an approach were applied to energy RD&D, due to the lack of top-down guidance and overall priorities, gaps in the RD&D and commercialization strategies could develop which may impede the eventual commercialization of energy technologies. To commercialize a new energy technology in a timely manner, we believe clear goals must be established, and an integrated, holistic approach, considering all issues needing resolution, must be applied.

One industry official said that because the laboratories have never shown a capability to commercialize a technology, industry should be able to use the laboratories as is done in West Germany. In West Germany, large-scale national research centers were established in the mid-1950s for nuclear power reactor development. Since the late 1960s these centers have diversified into other research areas including nonnuclear energy RD&D. Responsibility for all West German Government-funded RD&D rests with its Ministry for Research and

Technological Development. In 1976 this Ministry spent about \$450 million on nuclear energy RD&D and about \$95 million on nonnuclear energy RD&D. Ironically, however, a source having intimate familiarity with the West German model told us its structure for the most part was patterned after the DOE multi-program laboratories.

Under this model, the Ministry assigns each research center major missions. Within each mission, project management responsibilities are assigned for projects in the early phases of development--basic and applied research through determination of technical feasibility. As project manager, a research center directs all work related to the project, negotiates contracts for tasks to be carried out by industry, and provides funds directly to each entity carrying out the tasks including industry. Thus, they serve as funnels of funds. When technical feasibility is determined, industry is assigned project management responsibilities and uses the research centers for technical advice and research. For these projects, however, the Ministry provides project funds directly to each of the participants.

We believe that the laboratories should have a major role in the development of a nonnuclear energy technology up to the determination of technical feasibility and that industry should participate in all phases to facilitate technology transfer and eventual commercialization. We, therefore, believe that the laboratories should perform enough basic research to retain their capabilities and have a major role in the technology development phase. In carrying out their work, laboratories should make maximum use of industry for hardware and components needed. As a technology progresses to the engineering development phase, industry should assume a major role and the laboratories' role should be limited to providing assistance and advice.

SHOULD THE LABORATORIES HAVE THE
AUTHORITY TO CARRY OUT PROJECT
MANAGEMENT RESPONSIBILITIES?

A variety of opinions was given to us on this issue, ranging from none to complete responsibility for project management, such as in the NASA space flight mode.

Laboratory officials said they would like increased authority to make day-to-day decisions in their nonnuclear energy RD&D efforts in a manner similar to that they have had in their weapons and nuclear energy RD&D efforts, especially if they are to be responsible for the project. However, they said that whether they should have project management responsibilities would depend on the phase of development of the

projects and the degree of laboratory involvement. Hence, they believed the laboratories should have project management responsibilities for projects in the technology development phase, such as test facilities, and projects in the latter phases of development that industry could not or did not want to carry out. Laboratory officials said, however, they did not want to emphasize project management responsibilities because it would increase their administrative workload and tend to dilute their capabilities for carrying out R&D.

Most of the industry officials similarly believed that project management responsibilities should be delegated to those responsible for carrying out the work. However, they believed all large projects should be directed toward the marketplace; and industry, with its knowledge of the market, should have the major role. They pointed out that although industry should be involved to facilitate commercialization, Government funding is needed because the high cost and risk make economic payoff uncertain. Therefore, they believed that the Government should provide industry funds for such projects along with the authority to make the day-to-day project management decisions.

As previously mentioned, one industry and some university officials believed that the laboratories should have project management responsibilities in the NASA space flight mode. Under this mode, the laboratories would have project management responsibilities over all projects within assigned missions regardless of which entities carry out the work.

One university official believed that the laboratories should not have project management responsibilities, but their roles should be essentially data gathering.

Views on which entity should have project management responsibilities also varied among ERDA program managers. Some headquarters managers believed that project management responsibilities should be retained at headquarters because the delegation of such responsibilities would tend to dilute their essential control over the conduct of their programs. Others believed that the control could be retained if such responsibilities were delegated to the field operations offices, which are operated by Government employees. Still others believed that such responsibilities could be delegated to the laboratories or industry as long as the program manager retained control over major decisions affecting project direction, cost, and schedule.

ERDA's Field and Laboratory Utilization Study Group recommended that project management responsibilities be delegated to the field operations offices to place the day-to-day

responsibilities closer to the work site. In line with this recommendation, ERDA headquarters increased its delegation of such responsibilities to certain of these field offices. However, these field offices needed additional technical capabilities to manage the projects, and ERDA transferred some of its headquarters staff with technical management expertise to the operations offices assigned such responsibilities. In addition, these field offices have hired technical personnel, primarily professionals with expertise in technical project management from other Federal agencies.

For example, before being assigned project management responsibilities in June 1977, the San Francisco Operations Office increased its technical staff by 14 people from 79 in June 1976 to 93 in June 1977. However, because the laboratories have the technical expertise and the field operations office lacked sufficient in-house technical capability to carry out RD&D, the office delegated the technical management of the projects to various multiprogram laboratories. In their role as technical managers, the laboratories perform technical tasks such as developing project plans and requests for proposals, evaluating proposals, and monitoring technical aspects of contracts. On the basis of the results of each of these tasks, the laboratories make recommendations to the project manager. Hence, the laboratories serve in a technical advisory role to the operations office project manager. However, some headquarters program managers told us that, in effect, the laboratories often carry out project management responsibilities in the technical areas because the project managers never challenge their recommendations.

We also noted that the Chicago Operations Office has had a problem in effectively carrying out its duties, even without additional project management responsibilities. According to a June 1976 memorandum by an ERDA headquarters official, the Chicago Operations Office was not able to perform many of its key management functions. One example cited in the memorandum was that the office did not routinely monitor certain aspects of contractor performance nor did it become familiar with the technical areas in which the contractors were involved. This official attributed these shortcomings to a lack of staffing.

In response to our inquiry regarding the possibility of this office being delegated project management roles, a Chicago Operations Office official told us that his office, as a whole, is not qualified and would need courses to become familiar with project management, especially with the technical aspects.

Therefore, it is evident that before project management responsibilities could be delegated to certain field operations offices, a considerable buildup of talent would be required.

Even after such a buildup, the field operations offices would have to rely heavily on the technical advice of the laboratories.

In addition to delegating project management responsibilities to the field operations offices, ERDA headquarters had delegated such responsibilities for several projects to industry and the laboratories. As a result, the day-to-day decisions regarding these projects are being made at the work site. Therefore, it appears that there are at least two other options to placing the day-to-day decisions closer to the work site: have the headquarters project manager retain his oversight responsibilities, but delegate his authority to carry out the day-to-day project management responsibilities to industry, or have him delegate such authority to a laboratory.

The delegation of such authority to industry would increase its participation and enhance the possibilities of commercializing the technology. Hence, this option may be preferable in many instances, particularly for those projects in the engineering development and demonstration phases. However, because industry may lack interest or capability in a particular technology, or because a technology is not yet technically feasible, it may be preferable to delegate the authority to carry out project management responsibilities to a laboratory.

We believe that some of the laboratories are better suited than the field operations offices for carrying out project management responsibilities. Several laboratories already have a considerable amount of technical expertise that could be applied to nonnuclear energy RD&D. If their capabilities to address socioeconomic issues are enhanced, they would appear to have all the basic talents needed to carry out project management responsibilities. Some of the field operations offices, on the other hand, would have to significantly expand both their technical and socioeconomic capabilities.

We also noted that in the past, several of the multiprogram laboratories have carried out project management responsibilities and have met with considerable success. While some projects encountered problems, we believe that if the delegation of authority to carry out project management responsibilities is limited to assigned missions in certain technologies or technical areas, the laboratories could focus their capabilities on these areas, thereby better ensuring the chances of success for such projects. Accordingly, we believe that in areas in which the multiprogram laboratories are assigned missions, they should be provided the authority for managing selected projects.

SHOULD THE LABORATORIES BE USED FOR
FUNNELING MONEY TO UNIVERSITIES
AND INDUSTRY?

With the exception of those officials we contacted that favored the use of the NASA space flight project management mode, most officials involved in energy RD&D were not in favor of using the laboratories for funneling money to universities and industry.

Laboratory officials said that they already subcontract a substantial amount of their funds to industry and universities, with some, such as the weapons laboratories, subcontracting up to 40 percent of their funds for hardware and components. However, they pointed out that most of ERDA's, and now DOE's, nonnuclear energy RD&D funds are provided directly to industry by headquarters or the field operations offices. The officials believed that this was an appropriate role for these administratively oriented organizations and that the assignment of such responsibilities to the laboratories would increase their administrative responsibilities and tend to dilute their technical capabilities.

Most of the industry officials were against having funds funneled through the laboratories because they were concerned that the laboratories would keep the RD&D funds in-house. One university official similarly expressed concern that the laboratories would keep the basic research funds in-house. Some industry officials said that whoever controls the funds, controls the program and that DOE should not dilute its control over its programs by relinquishing control of funds.

The industry and university officials that favored the use of the NASA space flight model believed that funds should be funneled through the laboratories. They believed that specific limits could be established as to the amount of funds to be used in-house with the balance to be funneled to industry and universities. In this regard, we noted that ERDA had made such specifications in some interagency agreements involving the execution of project management functions.

DOE, and formerly ERDA, headquarters' workload has increased substantially in recent years, and DOE is now funneling some funds through laboratories such as NASA's Jet Propulsion Laboratory--a Government-owned laboratory, operated by the California Institute of Technology, located at Pasadena, California. This funneling of funds to other entities has helped in getting the funds out to industry faster. In its agreements with NASA, DOE has given the Jet Propulsion Laboratory management responsibilities in the NASA space flight mode and specified that funds are to be subcontracted to industry and

universities. We noted that for one project, the Jet Propulsion Laboratory had subcontracted about 70 percent of project funds.

In summary, it appears that the issue of funneling funds through laboratories is largely dependent on the delegation of project management responsibilities. Therefore, we believe that in cases where project management responsibilities are delegated to the laboratories, funds should be funneled to industry or universities, with only enough funds kept in-house to carry out those tasks needed to maintain a laboratory's capabilities and those which other entities cannot or do not want to do.

HOW EXTENSIVELY SHOULD THE LABORATORIES BE INVOLVED IN SETTING POLICY, PLANS, AND PRIORITIES?

The consensus of officials involved in energy RD&D that we contacted was that the multiprogram laboratories should provide information and advice to DOE officials setting policy, plans, and priorities. However, these officials cautioned that decisions as to DOE policy, plans, and priorities were the responsibility of DOE's management.

Laboratory officials believed that providing information and technical judgments to DOE officials for their use in making decisions is a proper role for the laboratories and pointed out that their role of providing such input did not include making decisions. Laboratory officials said that they had only limited input to ERDA's initial policy, plans, and priorities as set forth in ERDA-48, "A National Plan For Energy Research, Development, and Demonstration: Creating Energy Choices For the Future," June 1975. However, since the development of ERDA's initial plans, they have had increased input to various policy, planning, and priority decisions, and they were generally satisfied with their present level of involvement. ERDA officials explained that they usually obtain input from all available sources, but their initial national plan was developed in a short time frame and it was not possible to obtain the desired input from all sources.

Industry officials similarly believed that DOE should obtain input from all available sources and some of these officials acknowledged that they have had the opportunity to provide such input and were satisfied with their level of involvement. However, because the laboratories are closely associated with DOE, many industry officials expressed concern that the laboratories were too involved. They pointed out that the laboratories would establish DOE's policy, plans, and priorities and then turn around and compete for funds to carry them out.

University officials also believed that DOE should obtain input from all available sources and that the decisions should be made by DOE.

We agree that DOE should obtain input from all available sources in making its policy, planning, and priority decisions. Hence, we believe that the laboratories should continue to provide information and technical judgments to DOE officials making such decisions.

In addition to this input, due largely to a shortage of staff, ERDA headquarters obtained from the laboratories and industry, management support services, such as proposal specifications and evaluations, contract monitoring, and technical and administrative guidance for technical support work. No matter how heavily DOE relies on private industry or universities to carry out its RD&D, it must maintain a strong internal competence to direct and evaluate its programs. While final programmatic decisions must be made by DOE managers, even the best qualified managers must obtain technical advice from specialists because most RD&D decisions are based on technical facts and judgments. When DOE relies on such advice from persons outside of Government, potential conflict of interest situations can arise, and DOE's ability to retain essential control over the conduct of its programs tends to be diluted. Hence, it is important for DOE's managers to be able to obtain needed technical advice from within DOE. For DOE managers, one major source available for this technical knowledge is the multiprogram laboratories. Although contractor-operated, these laboratories are managed separately from the operating contractor's other activities, integrated into DOE's budgeting and accounting systems, and are required to observe any proprietary or other restrictions imposed on them by DOE. Thus, these laboratories function essentially as in-house facilities.

Accordingly, we believe that headquarters program managers should rely heavily on the laboratories for these management support services. By obtaining such assistance from the laboratories, headquarters program managers could concentrate their efforts on performing the management functions necessary to maintain essential control over the conduct of their programs.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

We noted that DOE's initial organizational alinement of the multiprogram laboratories is not conducive to their use in nonnuclear energy RD&D programs. In organizing its field offices and facilities, DOE alined three of the multiprogram laboratories to the Assistant Secretary for Defense Programs; two to the Director, Office of Energy Research; and three to the Under Secretary. The DOE activation task force initially proposed that each multiprogram laboratory be alined to an office responsible for specific research areas to focus the laboratories' efforts on programs within each laboratory's principal area of effort. The task force believed this would restrict the laboratories' involvement in other areas and the laboratories would eventually become specialized laboratories in their principal areas of effort. However, because no single principal area of effort could be identified for three of the multiprogram laboratories, such laboratories were not alined to a particular program Assistant Secretary or Office, but instead were alined to the DOE Under Secretary.

Upon DOE's establishment, DOE officials responsible for coordinating and overseeing the use of the multiprogram laboratories told us that they do not anticipate any significant change in the use of these laboratories. We believe that the multiprogram laboratories should continue to be involved in other areas of endeavor, particularly in nonnuclear energy RD&D, as well as in their present principal areas of effort. We believe, however, that the alinement of five multiprogram laboratories to an Assistant Secretary or Office responsible for specific programs may eventually restrict these laboratories' efforts to program areas for which the Assistant Secretary or Office to which they are alined is responsible. Hence, as originally intended by those proposing this organizational alinement, the multiprogram laboratories may eventually become specialized laboratories.

To optimally use the multiprogram laboratories' potential for providing solutions to the Nation's energy problems, these laboratories should not be alined to an office responsible for a specific programmatic area. Instead, we believe that to retain their multidisciplinary capabilities and to facilitate their use toward solving pressing national energy problems, these laboratories should be alined to a separate office such as the Office of the Under Secretary, which does not have responsibility for specific programmatic areas.

The eight multiprogram laboratories have developed a considerable amount of scientific and technical capabilities in their basic research and nuclear energy and weapons RD&D. These laboratories have large-scale, sophisticated research and development facilities, representing a capital investment of over \$3 billion, and large highly technical staffs. Although their capabilities in the socioeconomic sciences appear to be somewhat limited, it appears to us that the laboratories' capabilities can be applied to nonnuclear energy technologies. However, only about 8.9 percent of the laboratories' fiscal year 1977 outlays were associated with their efforts in nonnuclear energy RD&D programs and much of these efforts were relatively small tasks that focused on fragmented portions of technologies.

Our review showed that ERDA had not adequately defined the roles of the multiprogram laboratories in the nonnuclear energy programs. In nearly 3 years of existence, ERDA did not have in place an overall comprehensive management system which, in part, was designed to define the specific roles of multiprogram laboratories responsible for carrying out RD&D work needed to help solve this Nation's energy problems. In July 1977 ERDA issued a requirement for its organizational entities to implement its proposed system, commonly referred to as the Program Planning, Budgeting, and Review System, for the fiscal year 1979 budget cycle. However, upon DOE's establishment in October 1977, ERDA's system was replaced with a new system--the DOE Policy and Program Planning System.

DOE officials believe that as part of their new Policy and Program Planning System the role of the laboratories would eventually be defined, but it was not addressed in DOE's initial description of the system. In January 1978 DOE adopted those aspects of ERDA's system that are designed to define the role of the laboratories. In nearly 3 years of existence, ERDA encountered delays in developing its system and was not able to implement it. We are, therefore, concerned that DOE may similarly encounter delays unless sufficient management attention and emphasis are placed on the expeditious development and implementation of its system. In implementing the system, we believe that DOE should particularly emphasize those aspects of the system intended to define the roles of multiprogram laboratories in nonnuclear energy RD&D.

In the absence of clear role definitions, a number of factors has contributed to the laboratories' relatively small and fragmented efforts in nonnuclear energy RD&D: (1) the piecemeal determination of the laboratories' roles; (2) ERDA's and DOE's emphasis on using private industry for developing nonnuclear technologies; (3) the incompatibility of the laboratories' perceived roles with the Administration's increased

emphasis on the near- and mid-term energy technologies; (4) DOE's and ERDA's reluctance to expand the multiprogram laboratories; and (5) competition from other in-house research facilities.

We believe that a clear definition of each multiprogram laboratory's roles, including how it is to interface with other research entities, is needed. On the basis of our examination of issues related to defining the multiprogram laboratories' nonnuclear energy RD&D role, we believe DOE needs to make in-depth studies of the ramifications of assigning missions in nonnuclear energy technologies to its multiprogram laboratories, including the impact of such assignments on work being carried out by universities and industry. On the basis of such studies and its programmatic priorities, DOE should then assign appropriate missions in specific nonnuclear energy areas to those laboratories which have capabilities in those areas.

To accomplish certain mission assignments, the laboratories' infrastructures may have to be augmented by expertise in the various social and political sciences to make certain the socioeconomic, political, institutional, environmental, and legal implications are adequately considered during the development of the energy technologies. Such a holistic approach to energy RD&D is necessary to ensure that all ramifications of energy technologies, including those related to commercialization, are adequately considered and well understood before making major commitments to their development. We noted that DOE headquarters and field operations staffs involved in energy RD&D, like the laboratories, similarly have limited capabilities in the socioeconomic areas. Even if the tasks needed to address the socioeconomic issues are contracted to universities or industry, DOE needs in-house capabilities to effectively monitor and integrate such efforts. DOE, and formerly ERDA, have relied heavily on the laboratories for technical assistance and, on occasion, have also assigned them tasks involving socioeconomic issues, even though they appear to have limited capabilities for dealing with these issues. Hence, we believe that the laboratories' capabilities in the socioeconomic and political areas should be strengthened, consistent with the needs of their respective assigned missions, so they may assist in ensuring that an integrated, holistic approach to technology development is taken.

With respect to the laboratories' roles within assigned missions, the laboratories should have increased responsibilities. However, to facilitate commercialization of some projects, particularly demonstration projects, it may be more appropriate to delegate authority for carrying out project management responsibilities to industrial contractors. For projects in the early phases of a technology's development and for

projects that industry cannot or does not want to do, it may be impractical to delegate such authority to industry. In such cases, we believe that the authority should be delegated to the laboratories. To ensure that laboratories make appropriate use of industry and universities in carrying out such projects, project agreements should specify that project funds be subcontracted to the private sector.

In addition to carrying out increased project management responsibilities, the laboratories should have an expanded advisory role in their respective missions. ERDA headquarters' control over the conduct of its programs was diluted because it lacked the staffing and expertise to carry out essential management functions and sometimes contracted them out to industry. We believe that headquarters program managers should rely more on the laboratories for needed advice and technical assistance and concentrate their efforts on performing the essential management functions to maintain control over the conduct of the programs.

RECOMMENDATIONS

We recommend that the Secretary of Energy:

- Aline the eight multiprogram laboratories to a separate office, such as the Office of the Under Secretary, which is not responsible for specific programmatic areas.
- Closely monitor the development of the planning, programming, and budgeting system to ensure its timely implementation, giving particular attention and highest priority to those aspects which are intended to define the roles of the multiprogram laboratories and integrate such roles into DOE's energy RD&D efforts.
- On the basis of each laboratory's capabilities, make an in-depth assessment of the ramifications of assigning missions to the multiprogram laboratories in each of the nonnuclear energy technologies being developed.
- Based on such an assessment, assign to the multiprogram laboratories missions where appropriate, including specific support roles in areas where other research entities have greater capabilities.
- Consistent with such mission assignments, augment staff capabilities at the laboratories, and within DOE to include sufficient expertise in the various social, economic, and political sciences to make certain that all aspects of energy technologies are adequately considered in a holistic approach to their development.

- Delegate to the laboratories authority to carry out day-to-day management responsibilities for projects within their assigned missions that are not appropriate for industry. In these cases, closely monitor each laboratory's use of project funds to ensure that appropriate work segments are subcontracted to the private sector and other entities.
- Expand the multiprogram laboratories' advisory role within their respective assigned missions.

CHAPTER 6

DOE COMMENTS AND OUR EVALUATION

DOE's comments on the draft of this report focused on our recommendations and revisions have been made in this report to address its concerns. 1/ DOE strongly objected to our recommendation to align the eight multiprogram laboratories to a separate office which is not responsible for specific program areas. Further, DOE said it is "not clear" that augmentation of staff capabilities, consistent with the various missions, to include expertise in the social, economic, and political sciences, was needed. DOE generally agreed with the basic thrust of our other recommendations, which are designed to define the role of the laboratories in a manner which would provide greater interface between the laboratories and other research entities. In this regard, DOE pointed out that steps are already being taken to carry out these recommendations.

In regard to the proposed alinement to a separate office, DOE pointed out that the primary mission of the three weapons laboratories is nuclear weapons and not general energy. It noted that the intent of DOE's policy for overseeing the placement of work at the weapons laboratories is to ensure all energy program managers have access to these laboratories for energy-related work. Furthermore, it noted that DOE's Field and Laboratory Coordination Council provides for coordination of policy with respect to the use of the laboratories and provides the needed safeguards against the possibility of Assistant Secretaries diverting, monopolizing, or unduly specializing the activities of the laboratories assigned to them.

While the primary mission of the weapons laboratories has been nuclear weapons and the intent of DOE's policy for overseeing the placement of work at such laboratories may be to provide a mechanism for ensuring their availability to energy work, we continue to believe that the alinement of the laboratories to an Assistant Secretary responsible for a particular program or programs and the use of the work placement criteria has inhibited their work in other program areas.

For example, the Assistant Secretary for Defense Programs must ensure that the weapons laboratories remain available for carrying out nuclear weapons work, while at the same time making these laboratories available for all energy work. Although the amount of energy work has grown, this work has been scattered among several energy programs and often consists of

1/See appendix II for full text of DOE comments.

relatively small tasks focusing on fragmented portions of technologies. In this regard, officials at the laboratories told us that they have not been able to undertake any major additional energy work and that, even though funding for energy work has increased, their energy work has been generally limited to a continuation of those efforts already underway. Hence, it appears to us that the Acting Assistant Secretary for Defense Programs and his predecessor in ERDA have limited these laboratories' significant additional energy work for fear that such work would limit their availability for weapons work.

We agree that the availability of the weapons laboratories to carry out weapons work is a legitimate concern. However, we believe that ERDA's and DOE's approach to ensure their availability for weapons work has established a barrier toward also assigning those laboratories missions in energy work. We believe that if the laboratories were aligned to a separate office not responsible for a specific program, these laboratories could more readily be assigned significant missions in energy programs, without jeopardizing their weapons efforts.

In assigning such missions steps must be taken to ensure that each laboratory has the capabilities, including the capacity, to carry out each of its assigned missions. This may necessitate that some nonmission work, such as certain non-nuclear energy tasks, no longer be carried out by a particular laboratory. While this would most likely focus a laboratory's work on a relatively few program areas, we believe it would help provide that laboratory with the capability needed to provide innovative approaches toward solving problems in its assigned missions.

With respect to DOE's comments that the Field and Laboratory Coordination Council is to oversee and coordinate the laboratories' activities, we agree that this council may be able to ensure that the laboratories are made available for use by other program Assistant Secretaries. However, we believe that this council could have difficulty in getting the Assistant Secretary to which a laboratory is aligned to agree to have that laboratory assigned a significant mission in a program for which another Assistant Secretary is responsible. Accordingly, we believe that the multiprogram laboratories should be aligned to a separate office which does not have a programmatic bias when determining what the laboratories' missions should be.

In regard to our recommendation to augment staff capabilities in the various social, economic, and political sciences, DOE commented that such capabilities are available from other sources when and if needed. We agree that other sources capable of carrying out specific tasks involving these sciences

should be used when available. However, we believe that DOE and/or laboratory managers responsible for the various energy technology programs, or portions of those programs, should not have to rely exclusively on such sources in carrying out their management functions. Such reliance, in our opinion, would tend to fragment their approach to energy technology development.

To provide an integrated, holistic approach, considering all aspects of an energy technology's development, we believe that managers need staff capabilities on hand in all areas so they may have the expertise needed to effectively manage the development, and ultimately the commercialization, of a given technology.

Hence, regardless of the availability of other sources to carry out needed tasks, we believe that, consistent with assigned missions, DOE should augment staff capabilities at the laboratories, and within itself, to include sufficient expertise to ensure that, the socioeconomic, environmental, and institutional, as well as the technical, aspects are adequately considered.

CHAPTER 7

SCOPE OF REVIEW

Our review was directed toward evaluating the use of the eight multiprogram laboratories in developing new energy technologies to help solve the Nation's energy problems. In light of the recently created DOE, we also examined the potential impact it will have on the initiatives ERDA had taken to resolve the problems related to the use of the laboratories.

We made our review principally at ERDA and DOE headquarters, Washington, D.C., and at the eight multiprogram laboratories. We obtained information regarding the roles of laboratories from these organizations through discussions with responsible officials and reviews and analyses of documents they provided.

We also conducted work at three DOE field operations offices, two energy research centers, NASA headquarters, NASA's Jet Propulsion Laboratory and Lewis Research Center, and 25 industrial and educational organizations to obtain their views on the issues affecting the roles of the laboratories. In addition, we obtained views on the major issues affecting the roles of the multiprogram laboratories from nine of our consultants having expertise in energy research and development at universities, industry, and Government organizations.

MEMBERSHIP OF UNIVERSITYCONSORTIA OPERATING MULTIPROGRAM LABORATORIESArgonne National Laboratory - Argonne Universities Association

University of Arizona
 Carnegie-Mellon University
 Case Western Reserve University
 University of Chicago
 University of Cincinnati
 Illinois Institute of Technology
 University of Illinois
 Indiana University
 Iowa State University
 University of Iowa
 Kansas State University
 University of Kansas
 Loyola University
 Marquette University
 Michigan State University
 University of Michigan
 University of Minnesota
 University of Missouri
 Northwestern University
 University of Notre Dame
 Ohio State University
 Ohio University
 Pennsylvania State University
 Purdue University
 St. Louis University
 Southern Illinois University
 The University of Texas at Austin
 Washington University
 Wayne State University
 University of Wisconsin

Brookhaven National Laboratory - Associated Universities, Inc.

Columbia University
 Cornell University
 Harvard University
 The Johns Hopkins University
 Massachusetts Institute of Technology
 University of Pennsylvania
 Princeton University
 University of Rochester
 Yale University



FEB 23 1978

Department of Energy
Washington, D.C. 20545

Mr. Monte Canfield, Jr., Director
Energy and Minerals Division
U.S. General Accounting Office
Washington, DC 20548

Dear Mr. Canfield:

We appreciate the opportunity to review and comment on your draft report entitled "The Multiprogram Laboratories: A National Resource Needing a Nonnuclear Energy Role." We have reviewed the draft with members of your staff and we understand that a number of changes and clarifications which we suggested will be made. Our views with respect to the recommendations made by GAO are discussed below.

We object strongly to the GAO recommendation that the Secretary of Energy "align the eight multipurpose laboratories to a separate office which reports to the Secretary, or his designee, and is not responsible for specific program areas." The recommendation is apparently based on two erroneous assumptions. The first is that all the laboratories have a common energy mission and the second is that the assignment of a laboratory to an Assistant Secretary responsible for certain programs would restrict the laboratories' involvement in other areas. Five of the eight laboratories do have energy as a primary mission; however, the primary mission of the three weapons laboratories is nuclear weapons - not general energy. This assignment stems from Section 92 of the Atomic Energy Act which prohibits pursuit of nuclear weapons activities except under the auspices and stringent control of the DOE and DOD. To ensure stringent controls, the R&D part of the nuclear weapons program is carried out exclusively in these three laboratories and they represent the Nation's sole capability for nuclear weapon R&D.

Further, the President's 1976 recommendation to the Congress (in response to Section 307 of the Energy Reorganization Act of 1974) reaffirmed the nuclear weapons program as the primary role of these laboratories and since Section 209 of the DOE Act also recognized this primary role the DOE continued this assignment unchanged.

Contrary to the second GAO assumption, the present policy on DOE oversight responsibilities for placement of work in the weapons laboratories was implemented to avoid limitations on access by all energy programs. All program sponsors have the responsibility and authority to deal directly with the laboratories to formulate possible non-weapons, including non-nuclear energy, tasks and review laboratory workload and manpower projections

Mr. Monte Canfield, Jr.

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to incorporate their needs. The intent of the policy is not to restrict but to encourage laboratory participation in energy programs. Experience in ERDA, particularly in the weapons laboratories, led to the present system of assigning laboratories.

Based upon experience, it is our opinion that the assignment of the laboratories to programmatically related Assistant Secretaries does not result in limited contribution by a laboratory to the overall energy mission, as feared by GAO.

Further, our Field and Laboratory Coordination Council (FLCC) provides for coordination of policy with respect to utilization of the laboratories and provides the necessary safeguards against the possibility of Assistant Secretaries diverting, monopolizing or unduly specializing the activities of the laboratories assigned to them. In this sense, the role of the FLCC and its Secretariat essentially achieves the balance and oversight responsibility felt by GAO to be necessary.

There are pros and cons for any of the alternative ways of assigning or aligning the laboratories. The alignment adopted by DOE contains, in our opinion, no basic problems or disadvantages and provides the necessary coordination and safeguards to ensure proper utilization and participation of the laboratories in energy work.

The second recommendation to "closely monitor the development of the planning, programming, and budgeting system to assure its timely implementation, giving particular attention and highest priority to those aspects of the system which are intended to define the roles of the multi-program laboratories and integrate such roles into the agency's energy RD&D efforts," recognizes that work in this area was underway and that the work and effort carried out by ERDA had not been abandoned but was being utilized as appropriate in the DOE management system. There is, and has been, a substantial effort to integrate planning, programming and budgeting. Also, the defining of the roles of the laboratories and integrating such roles into our R&D efforts is already being done as a part of the recently adopted Institutional Planning process.

Such an undertaking is very complex at best and the newness of the Department has added to the complexities. We acknowledge that our efforts to better integrate our overall management system have not been completed and we are actively working to put our system in place.

With respect to the third and fourth recommendation for an assessment of the capabilities of each laboratory and what roles each will have in the nonnuclear energy programs, the roles of each laboratory, including consideration of capabilities, is already underway as part of our Institutional Planning and as part of our effort of assessing technology base assignments.

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In regard to the fifth recommendation to augment staff capabilities, consistent with the various missions, to include expertise in the various social, economic, and political sciences, it is not clear that additional capability of this type is needed at the laboratories or that any special effort is needed to augment the capability within the agency. Such capabilities are available from a variety of sources when and if they are needed and these areas of concern to GAO will be adequately considered.

The sixth and seventh recommendations concern the delegation of day-to-day management responsibilities to the laboratories and the expansion of their advisory roles. A major effort is now underway to delegate more management responsibilities to the field utilizing the combined capabilities of our field operations offices and the laboratories. With respect to expanding the advisory role of the laboratories, our program managers have utilized the laboratories in this role and this practice will continue and is expected to increase. The Field and Laboratory Coordination Council will, in addition to the efforts of the Assistant Secretaries, provide an overview of laboratory activities and will help assure the appropriate utilization of the laboratories with respect to the private sector and other entities.

Sincerely,



Fred L. Hiser, Director
Division of GAO Liaison

(30034)