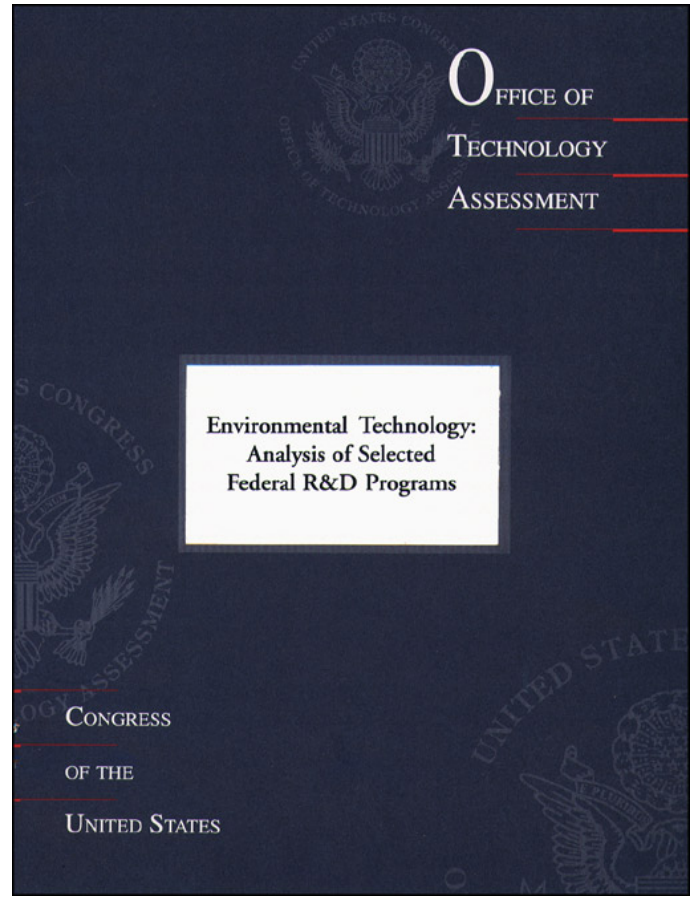
Environmental Technology: Analysis of Selected Federal R&D Programs

July 1995

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Foreword

In recent years, federal agencies have given increasing attention to environmental technology research and development (R&D). The Department of Energy and the Department of Defense account for the lion's share of the spending on environmental technology R&D and precommercial demonstrations, but six other departments and agencies spent more than $30 million each on such activities in fiscal year 1994. The total spent is debatable, given different assumptions about what projects count as environmental technology, but the 1994 estimates range between $2.5 billion and $3.5 billion. (Total federal R&D expenditures for *all* purposes in 1994 exceeded $70 billion).

Getting the federal government's own environmental house in order is one rationale for this R&D. Federal agencies now spend several billion dollars a year to clean up or manage wastes at their facilities, and to operate in compliance with environmental requirements. The R&D could result in more cost-effective technologies that could help lower future expenditures or help agencies address specialized problems more effectively. Several federal agencies also conduct or support R&D on technologies that could help state and local governments or the private sector reduce the environmental impact of their activities, with the largest amount by far aimed at reducing the significant environmental impact of energy production and use.

This Background Paper responds to a request by the staff of the House Committee on Science for information about federal environmental technology R&D programs. It discusses estimates of environmental technology R&D spending, interagency coordination mechanisms, and major federal programs, including programs administered by the Department of Energy, the Department of Defense, the Environmental Protection Agency, and several other agencies. The analysis is by no means comprehensive; evaluation of program effectiveness was outside the scope of this paper. The Background Paper is the first product in a broader assessment of development and diffusion of innovative environmental technologies requested by the Science Committee and the Senate Environment and Public Works Committee. The final report in this assessment is due in the spring of 1996.



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Introduction 1

Over the past decade, increasing attention has been paid to environmental technology, reflecting demands for improvement in environmental quality, and recognition of the growing costs of treating waste and pollution, sometimes to meet stricter standards. Innovative or more cost-effective environmental technologies are being pursued on several fronts: improvements in add-on technologies to control pollution before it enters the environment; development of new or less costly technology to treat or clean up waste after it enters the environment; and development of cleaner technologies, or pollution prevention approaches, that produce less waste and pollution in the first place and are often more energy efficient than conventional control technologies. The need for specialized technologies to clean up hazardous or radioactive wastes resulting from nuclear weapons research and production also has been an impetus for research and development (R&D).

In response to such demands, federal funding for environmental technology research, development and demonstration (RD&D) has expanded. According to a Clinton Administration estimate, the federal government spent over $3.5 billion in FY 1994 and about $3 billion in FY 1993 on environmental technology RD&D. Because these are baseline figures, it is not clear how environmental technology RD&D spending would compare with spending in prior years. However, under the Clinton Administration, environmental technology has become a more prominent component of federal policy affecting technology development. The most recent Administration initiative—a national environmental technology strategy—was announced in April 1995.

Environmental protection is a crosscutting issue. Several different agencies, including the Department of Energy (DOE), the

Department of Defense (DoD), the Environmental Protection Agency (EPA), and the Department of Commerce (DOC), have placed increased emphasis on environmental technology R&D. Involvement of these and other agencies generally falls into one or more broad categories:[1]

1. *Developing technologies to help federal agencies comply with environmental requirements, or clean up and manage wastes at federal facilities*. Federal agencies now spend several billions of dollars each year on environmental compliance, cleanup, and waste management, especially for management of radioactive and hazardous wastes at DOE and DoD facilities. Estimates of future clean up and restoration costs at Federal Facilities using current technology extend into the hundreds of billions dollars. Some funds are now directed to development of innovative or potentially less costly cleanup or restoration technologies, or potentially less costly compliance approaches such as pollution prevention.
2. *Encouraging development and diffusion of less costly and more effective environmental technologies for use by business, local governments, and consumers in abating and controlling pollution or waste.* Most environmental technologies are developed to meet government-imposed regulatory requirements. The direct costs of complying with U.S. pollution abatement and control requirements have been estimated at $90 billion to $120 billion per year. Effective, yet less costly, environmental technologies, might reduce future growth in this burden, while contributing to the social return from environmental investments.
3. *Encouraging development of environmentally preferable technologies—often called pollution prevention or cleaner technologies—for use by industry and consumers.* Many federal agencies undertake or support R&D in areas related to their mission, such as energy, transportation, agriculture, and mining. Efforts are underway to encourage these and other agencies to support R&D that could lead to innovations that are preferable from an environmental standpoint because they use less energy, produce less waste, and/or find productive use for by-products.
4. *Promoting U.S. exports of environmental technologies for their domestic economic benefits and to foster environmentally sustainable development throughout the world*.

Often a mixture of such efforts exists in an agency, or a given effort may apply to several of these purposes. For example, in some cases, innovative technologies developed for cleanup at federal sites may also be appropriate for private sector use, here and abroad. Table 1-1 shows environmental technology activities of selected federal agencies or entities.

With the expansion of federal environmental technology activities, questions about program coordination, potential for duplication of efforts, and priorities for allocation of limited federal R&D resources have become more prominent. While the Administration sought increased funding for some environmental technology programs in its proposed FY 1996 budget, rollback or, in some cases, zeroing out funding for some of these programs is proposed in several appropriations bills under consideration in the 104th Congress.

There are also sharp philosophical disagreements in Congress about the appropriate role for federal RD&D. For example, few would disagree in principle with use of federal R&D funds to develop specialized technologies that might lower the high costs of federal facility cleanup when those technologies are not available commercially. However, there is continuing debate about what priority to give to federal site cleanup, and what standards for cleanup should apply. For

[1]The federal government also spends substantial sums to advance environmental science and understanding through development and deployment of technologies to monitor and model physical, chemical, and biological processes. R&D on such technologies, which include earth observation satellites and climate models, are sometimes included in estimates of environmental technology spending, but are not addressed in detail here.

TABLE 1-1: Key Federal Agencies with Environmental Technology RD&D Responsibilities

National Science and Technology Council
- Government-wide strategy development
- Coordination through:
  —Committee on Environment and Natural Resources
  -Committee on Civilian Industrial Technology
  —Working Group on Environmental Technology
  —Interagency Environmental Technologies Office
- Multiagency activities

Department of Energy
- Cleanup and restoration technologies for current and former DOE facilities
- Technologies for cleaner production, generation, and use of fossil energy
- Energy efficiency technologies for use in buildings, utilities, transportation, and industry
- Solar and renewable energy technologies
- Transfer of DOE-developed technologies to public and private sectors

Department of Defense
- Cleanup and restoration technologies for current and former DoD facilities
- Technologies to bring DoD facilities and operations into compliance with environmental laws
- Technologies to further internal steps to reduce compliance and operation costs through pollution prevention and energy efficiency
- Transfer of DoD-developed technologies to public and private sectors

Environmental Protection Agency
- Adaption of the regulatory system to lower barriers to technological innovation
- Encouragement of technology partnerships with public and private sectors
- Evaluation of innovatwe technologies for Superfund and some other purposes
- Media specific activities to support regulatory functions

Department of Commerce
- Encouragement of environmental technology exports
- Development of monitoring technologies to keep track of oceanic and atmospheric environmental conditions
- Measurement and reference standard technologies pertinent to the environment

National Aeronautics and Space Administration
- Technologies for global monitoring of environmental conditions
- Technologies for lowering the environmental impact of aircraft

Department of Interior
- Recycling technologies and environmentally preferable technologies and approaches to extract, process, and use nonfuel minerals
- Water conservation technologies

Department of Agriculture
- R&D in support of environmentally preferable ways to conduct agriculture and forestry, and to deal with the related wastes from these activities

SOURCE: Office of Technology Assessment, 1995.

example, cleanup standards might vary depending on the anticipated future land use on a site.

The most intense debate surrounds use of federal R&D funds to encourage development of environmentally preferable technologies for private sector use. Some view these government R&D efforts as an inappropriate manifestation of industrial policy, and are concerned about government unwisely influencing technology choices that should be left to the private sector. Another criticism holds that these programs amount to corporate welfare. Others see environmental technology as a special case, especially when technologies are developed to comply with government regulations to achieve the societal objective of environmental protection. The issue is complex because

the distinction between environmental technologies and advanced production technologies is often murky; some innovative technologies and process changes that are most desirable from an environmental standpoint may also be more productive or efficient than previously used technologies.

This report is intended to provide information helpful to Congress as it examines several issues surrounding environmental technology R&D programs. It is the first product in a broader Office of Technology Assessment (OTA) assessment, requested by the House Committee on Science and the Senate Committee on Environment and Public Works, on the development and diffusion of innovative environmental technology, scheduled for completion in the Spring of 1996.[2]

This paper responds to interest expressed by staff of the House Committee on Science for interim information about federal agency environmental technology programs. The paper discusses key federal environmental technology strategies, programs, and coordinating mechanisms. The primary focus is on direct federal support for research, development, and demonstration activities, as well as, to a lesser extent, programs that support testing, evaluation, and verification of the performance of environmental technologies. The role, both positive and negative, that environmental regulations play in environmental technology innovation is discussed in other OTA work, and is not addressed in detail in this paper.[3] Other federal programs affecting environmental technology, such as export promotion, also are not discussed in detail.[4]

The next chapter discusses the overall environmental technology RD&D spending by the federal government, and efforts to develop government-wide strategies and coordinating mechanisms. Subsequent chapters discuss key federal departments and agencies with major environmental technology R&D programs. These chapters are organized on a department-by-department or agency-by-agency basis. The list of programs covered is by no means comprehensive in terms of broader definitions of environmental technology. Not covered, for example, are mass transit, many technologies associated with land and other resource management, most nuclear waste management R&D, earth monitoring technologies, and climate modeling.

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[2] The final report of the assessment will focus on public and private roles in providing environmental technical assistance.

[3] See U.S. Congress Office of Technology Assessment, *Industry, Technology, and the Environment: Competitive Challenges and Business Opportunities*, OTA-ISC-586 (Washington, DC: U.S. Government Printing Office, January 1994). In addition, an OTA report on new approaches to environmental regulation is forthcoming this summer.

[4] See ibid for fuller treatment of these aspects of environmental technology policy, and comparative information about public and private environmental technology research and development spending in the United States, Europe, and Japan.

Federal R&D Trends and Interagency Activities

2

At least five federal departments and three independent agencies have important roles in environmental technology research and development (R&D). This chapter discusses overall estimates of federal agency environmental technology spending and the limitations of current data. It also discusses interagency coordination mechanisms and strategy development efforts.

FEDERAL FUNDING FOR ENVIRONMENTAL TECHNOLOGY

Meaningful estimates of federal R&D spending on environmental technology are difficult to develop. The main reason is that definitions of "environmental technology" vary, and applying definitions in practice often involves subjective judgments.[1] Also, several agencies and programs fund or conduct R&D; in some cases, a close examination of all projects funded under a

[1]The Clinton Administration's environmental technology strategy defines environmental technology as:

> "technology that reduces human and ecological risks, enhances cost effectiveness, improves process efficiency, and creates products and processes that are environmentally beneficial or benign. The word 'technology' is intended to include hardware, software, systems, and services. Categories of environmental technology include those that avoid environmental harm, control existing problems, remediate or restore past damage, and monitor and assess the state of the environment."

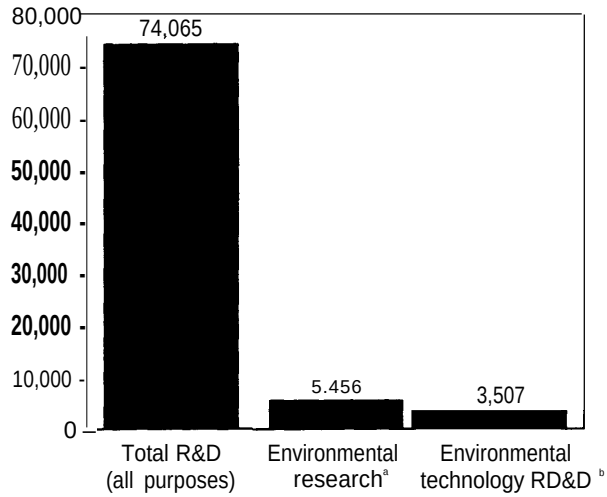
The definition is set forth in, National Science and Technology Council, *Bridge to A Sustainable Future: National Environmental Technology Strategy* (U.S. Government Printing Office, Washington, DC, April 1995), p. 3. On the difficulties in classifying environmental technologies, see U.S. Congress Office of Technology Assessment, *Industry, Technology, and the Environment*, OTA-1SC-586 (Washington, DC: U.S. Government Printing Office, January 1994), pp. 75-79.

R&D program not ostensibly environmental in nature would reveal some environmental projects. While some efforts have been made to distinguish between focused projects—those undertaken primarily for environmental reasons—and projects for which environment is only a contributing objective, the border lines are often fuzzy.

A further complication is that federal environmental technology activities range across a spectrum, stretching from basic research, through applied research, technology development and demonstration, to technical assistance or other forms of help to end users. To develop an accurate picture of federal environmental technology R&D, analysts would need to conduct a crosscutting analysis of all potentially relevant projects using consistent definitions of environmental technology and a sharp delineation of countable activities.

A systematic estimation process, using consistent criteria and procedures government-wide, has yet to be implemented on a continuing basis. However, two interagency data collection efforts, both coordinated by the White House Office of Science and Technology Policy (OSTP) in 1994, do shed light on federal environmental technology R&D expenditures. One of the data collection efforts, conducted by a coordinating group called the Committee on Environment and Natural Resources (CENR), asked federal agencies with primary missions for environment and natural resources to report all of their environmental research activities (from basic scientific research through environmental technology development). The other data collection effort, referred to below as the TSF data because it was used in the Clinton Administration report, *Technology for a Sustainable Future (TSF): A Framework for Action*[2], was specifically aimed at identifying federal environmental *technology* expenditures. The two sets of data are not entirely comparable: however, they did provide government-wide estimates for the first time.[3] (Figure 2-1 shows these estimates in comparison with the total for *all* federal R&D for all purposes in FY 1994).

FIGURE 2-1: Federal Agency Expenditures: All R&D, Environmental Research, and Environmental Technology R&D, FY 1994 ($ millions)



[a] Environmental research includes activities identified for the Committee on Environment and Natural Resources of the National Science and Technology Council, plus Department of Defense environmental technology spending.
[b] Environmental technology RD&D derived from NSTC's Technology for *a Sustainable Future* report.

SOURCE: National Science Foundation, *Federal Funds for Research and Development: Fiscal Years 7992, 1993, and 1994, Volume 42,* NSF 94-328 (Arlington, VA: 1993), table C-2, pp. 33-35; and National Science and Technology Council, Committee on Environment and Natural Resources, unpublished tables, 1994

The CENR estimated that federal agencies with primary missions for environment or natural resources spent more than $5 billion on their environmental research and development in FY 1994. However, it is not clear how much of this was for environmental technology R&D. Moreover, the CENR data did not include the Department of Defense (DoD), which has major environmental

[2] National Science and Technology Council, *Technology for a Sustainable Future: A Framework for Action* (Washington, DC: U.S. Government Printing Office, 1994).

[3] Another round of data collection on environmental technologies is under consideration by the Clinton Administration.

TABLE 2-1: Clinton Administration Estimates of Federal Agency Environmental Technology Spending,[a] FY 1994 ($ millions)

	DoD	DOE	EPA	NSF	DOC	NASA[b]	DOI	USDA	Other[c]	Total[d]
R&D	206	1,059	56	34	190	791	116	251	41	2,745
Demonstration	176	506	38	0	18	0	18	2	5	762
Subtotal	**382**	**1,565**	**94**	**34**	**208**	**791**	**134**	**253**	**46**	**3,507**
Scaleup	60	3	11	0	0.5	0	1	1	0	77
Commercialization	66	13	8		2	2	0.2	8	18	116
Subtotal	**126**	**16**	**19**	**0**	**3**	**2**	**1**	**9**	**18**	**193**
Other										
Education & training	4	16	3	6	2	16	2	501	3	551
Information dissemination		5	16		8	10	3	1	1	43
Market stimulation			9			7	1			16
Export promotion		3	7							11
Foreign aid	10		0.2		1				160	170
Subtotal	**14**	**24**	**35**	**6**	**11**	**33**	**6**	**502**	**164**	**791**
Total[d]	**522**	**1,604**	**148**	**40**	**220**	**825**	**142**	**764**	**228**	**4,491**

[a] Estimates cited above may differ from other estimates for the same agencies in FY 1994 due to differences in methodologies, definitions, or programs covered in data collection These estimates were finalized at the mid-point of the fiscal year, actual expenditures could differ from what was anticipated at the mid-point.
[b] NASA figure includes instrumentation in aircraft and Earth orbiting spacecraft systems to monitor global environmental changes and also includes R&D for access to the Earth Observing Information System
[c] Includes the Department of Transportation, the National Institute of Environmental Health Sciences, Smithsonian Institution; Tennessee Valley Authority; and US Agency for International Development
[d] Figures may not add due to rounding

Key: DOC=Department of Commerce; DoD=Department of Defense; DOE= Department of Energy; DOI=Department of interior, EPA= Environmental Protection Agency; NASA= National Aeronautics and Space Administration; NSF= National Science Foundation, USDA=U.S. Department of Agriculture

SOURCE: National Science and Technology Council, unpublished data, Apr. 6, 1994.

technology expenditures. Despite these limitations, the CENR effort produced detailed information about R&D projects for which environmental technology was the primary focus and projects for which environmental technology was a contributing objective.

The TSF estimates were specifically aimed at environmental technology. All the major federal agencies conducting environmental technology R&D, including the Department of Defense, responded. However, it is questionable whether some items reported through the TSF should be considered environmental technology.

Table 2-1 summarizes the TSF data. The TSF data suggests that anticipated federal spending for *all* environmental technology-related activities was nearly $4.5 billion in FY 1994. (The information was compiled at the mid-point of the fiscal year). Of the total, $2.75 billion was for R&D; another $762 million was expected to be spent for demonstration projects. Hence, the TSF total for environmental technology research, development, and demonstration (RD&D) was about $3.5 billion in 1994. Another $77 million was expected to be spent on scaleup, and an additional$116 million was expected to be spent on commercialization; most of the scaleup and commercialization expenditures were incurred by the Department of Defense. (The remaining TSF funds were for activities related to education and training, market

BOX 2-1: Key Categories of Environmental Technology R&D

The Clinton Administration has identified four categories of environmental technology RD&D: pollution avoidance, remediation and restoration, pollution control, and monitoring and assessment. The proportions of federal RD&D that fall into each category is uncertain, due to definitional problems and possible under- or over-reporting in different categories. The high proportion attributed to monitoring and assessment technology, especially, is questionable. In the discussion below, OTA has relied on actual callout data produced through the interagency process for the Technology for *a Sustainable Future* (TSF) report, rather than the percentages specified in the TSF report.[1]

Of the TSF estimate for RD&D, more than half—$1.8 billion—was called pollution *avoidance technology:* a broad term encompassing pollution prevention[2], energy efficiency, water conservation, and technologies for recycling or recovery of energy waste streams, products or raw materials. Of the avoidance total, most was for energy efficiency and cleaner energy programs sponsored by the Department of Energy (DOE). Some DOE R&D is also for industrial waste minimization (roughly equivalent in DOE parlance to pollution prevention). Pollution prevention often reduces compliance costs relative to conventional control technologies. The Department of Defense (DoD) also conducts or supports substantial RD&D on pollution prevention-about $130 million in FY 1994--as well as an additional $50 million to scaleup processes. Much of this R&D, such as development of less polluting and nontoxic approaches for surface cleaning and degreasing, could reduce DoD costs for environmental compliance.

Remediation and restoration technology accounted for about $537 million of the total-of which DOE and the Department of Defense accounted for a majority of the spending. RD&D for end of pipe pollution *control technology* amounted to about $195 million, with DOE and DoD again the largest funders.

The TSF data also shows over $1 billion in expenditures for *monitoring and assessment technology.* About three-fourths of this expenditure was for development of space, aircraft, and ground observational technology by the National Aeronautics and Space Administration (NASA) and the National Oceanic and Atmospheric Administration (NOAA) to track global environmental conditions. Whether those expenditures should be allocated to environmental technology is a matter of judgment. In this report, OTA does not consider these NASA and NOAA activities to be environmental technology expenditures.

SOURCE: Office of Technology Assessment 1995

[1] The *Technology for a Sustainable Future* report presented pie charts specifying proportions of the total RD&D budget for environmental technology devoted to specific categories such as avoidance technologies. OTA has elected to use the callout data for clarity.

[2] Approaches that seek to prevent generation of pollution and waste in the first place.

stimulation, information, development assistance and export promotion; these activities are not discussed in detail in this report).[4]

The TSF classifies the RD&D and scaleup activities under four broad categories: pollution avoidance, remediation and restoration, control, and monitoring and assessment. These categories are discussed in more detail in box 2-1.

As mentioned, estimates of environmental technology spending are a matter of definition. The very large TSF estimate of monitoring and assessment R&D (over $1 billion) includes $638

[4] The TSF data shows about $800 million in these categories. Of these funds, the largest amount by far ($501 million) was attributed to education and training funded by the U.S. Department of Agriculture (USDA). The TSF report does not explain why USDA would have such large expenditures for environmental technology education and training. In addition, about $170 million, was expected to be spent on foreign aid related to environmental and energy efficiency technologies, primarily through the U.S. Agency for International Development.

TABLE 2-2: Environmental Technology RD&D Programs Covered In this Report[a]

Program	FY 1994 ($ millions)
Department of Energy[b]	
Clean Coal Demonstration Program	$222
R&D pertinent to cleaner fossil fuels	314
Solar and Renewable Energies	219
Environmental Management Technology Development Program	215
Energy Efficiency	334[c]
Subtotal	**1304**
Department of Defense[d]	
Strategic Environmental R&D Program	154
Environmental Security Certification Program	—
Advanced Research Projects Agency	68[e]
Individual Services (total)	178
Subtotal	400
Other departments/agencies	
Environmental Protection Agency	94
Department of Commerce	43[f]
National Aeronautics and Space Administration	153[f]
Department of Health and Humann Services	11
Department of Interior	44
National Science Foundation (environmental technology R&D)	34
U.S. Department of Agriculture	240
Subtotal	714
Total	**$2,419**

[a]Funding estimates cited above may differ from other estimates for specific agencies in FY 1994 due to differences in methodologies, definitions, and jurisdictions covered in data collection.
[b]Figures do not include activities carried out through the Office of Energy Research (such as global change research), the Office Of Assistant Secretary for Environment, Safety, and Health, the Bonneville Power Administration, and some other program.
[c]Figure includes funding related to the Partnership for a New Generation Of Vehicles and for building technologies.
[d]Information provided by the Department of Defense.
[e]Figure does not include $10 million in appropriated but unreleased funds
[f]Figure does not include monitoring and assessment technology.

SOURCE: Office of Technology Assessment, 1995; based on information provided by federal agencies, and data collected by the National Science and Technology Council

million for National Aeronautics and Space Administration (NASA) projects to track global environmental conditions, not emissions from factories or vehicles. But some other kinds of research that might lead to environmentally preferable technologies might well have been omitted.

OTA has been more selective in identifying programs to be covered in this report. As shown in table 2-2, federal spending for programs discussed in subsequent chapters amounted to about $2.4 billion in FY 1994. Most of this was for energy efficiency or cleaner energy technologies, followed by remediation technologies. Table 2-2 does not include NASA or National Oceanic and Atmospheric Administration (NOAA) programs to monitor global environmental trends—a significant difference with Clinton Administration estimates.[5] Some other items that may have been

[5]For information about these NASA programs, see Office of Technology Assessment, *Global Change Research and NASA's Earth Observing System*, OTA-BP-ISC-122 (Washington, DC: U.S. Government Printing Office, November 1993).

identified as environmental technology in the TSF data, such as modeling related to global change research, also are not addressed here. Another contrast with TSF is that the DoD and DoE estimates in table 2-2 are reported on a program basis. The limitations of the program estimates in table 2-2 need to be understood. In the case of DOE, only major programs are covered in the table. Also, not all of the expenditures for programs listed in the table are for environmental technology R&D. Nevertheless, from the standpoint of policymaking, it would be useful for the data to be compiled on both a program basis and a project or activity basis (as some agencies did for the CENR). In the event that the executive branch again assembles data on crossagency environmental technology expenditures, it would be helpful if all agencies also reported expenditures on a program-by-program basis.

INTERAGENCY COORDINATION MECHANISMS AND STRATEGIES

Many different federal agencies have environmental technology responsibilities. The Department of Energy (DOE) and the DoD are the largest funders of environmental technology R&D. Numerous other agencies, including Environmental Protection Agency (EPA), the Department of Commerce, NASA, and the National Science Foundation (NSF) also support or conduct environmental technology R&D. Several environmental technology programs are multiagency efforts, although one agency may have lead responsibilities. For example, EPA is the lead for the Environmental Technology Initiative (ETI), but several other agencies receive ETI funding.[6]

Some federal technology programs that are not primarily environmental in nature also may on occasion fund projects that have such potential for large environmental benefits that they could be seen as environmental technology. For example, the Advanced Technology Program (ATP), a Department of Commerce program, is sponsoring R&D for development of more efficient refrigeration systems that would have the lowest achievable environmental impact. DoD's Technology Reinvestment Program (TRP) also has funded several projects or programs pertinent to environmental technology.[7]

In addition, informal alliances and partnerships among the agencies themselves and with other levels of government and/or the private sector have become common—leading some to refer to "virtual agencies" put together on a project-by-project basis to address environmental issues. The "virtual agency" concept also is being applied by federal laboratories as they conduct R&D on a cooperative basis with industry.

A commonly voiced criticism of federal environmental technology programs has been the absence of an overall strategic vision to guide agency actions. Recently, federal agencies have made efforts to develop environmental technology strategies, throughout the executive branch, and in several individual departments and agencies. The strategy development process resulted in the issuance of a national environmental technology strategy by the Clinton Administration in April 1995. (The strategy and the process that produced it are discussed in box 2-2.) In addition, several interagency coordinating mechanisms have also been set up to facilitate cooperation on environmental technology issues, both among the agen-

[6] The program was funded at $36 million in FY 1994, of which about $15 million involved partnerships with other federal agencies. The FY 1995 budget is $68 million; about $17 million of this will go to fund a series of innovative technology projects in the National Action Plan for Global Climate Change. The Clinton Administration sought an increase in ETI funding for FY 96; however, a reduction or elimination of the program is being considered by Congress. (See, for example, H.R. 1814, as introduced on June 13, 1995). The ETI is described in more detail in the section on the Environmental Protection Agency.

[7] Congress is considering FY 1996 funding cutbacks for both ATP and TRP.

BOX 2-2: Federal Environmental Technology Strategies

An ambitious effort to develop federal agency strategies for environmental technology, underway in the executive branch since at least 1993, culminated in the release by the Clinton Administration in April 1995 of a national environmental technology strategy, entitled *Bridge to a Sustainable Future.*[1]

The interagency effort to develop this strategy was orchestrated through National Science and Technology Council (NSTC). In August 1994, NSTC issued a report, Technology *for a Sustainable Future,* which identified four areas for federal action related to development and diffusion of environmental technology:

1. Using research, development, and demonstration projects to facilitate a shift from control technologies and waste management to avoidance approaches and resource conservation throughout the technology life cycle.
2. Using regulatory and fiscal policies to stimulate the development of environmental technologies and work to expand their diffusion.
3. Using export promotion and aid policies to increase the U.S. share of the global market for environmental technologies,
4. Using partnerships, education and training, and information dissemination, in addition to regulatory drivers, to influence the market for environmental technologies.

To get input for the national environmental technology strategy, NSTC held about 30 workshops and met with stakeholders and interest groups across the country. One such meeting was a White House conference on environmental technology held in December 1994.[2]

Another interagency effort, undertaken by the Department of Commerce (DOC), the Department of Energy (DOE), and Environmental Protection Agency (EPA), articulated actions federal agencies could take to promote exports of U.S. environmental technologies. Called *Environmental Technologies Exports: Strategic Framework for U.S. Leadership,* the November 1993 document identifies 18 technical and financial actions the government could take.

In addition, some departments and agencies, including EPA, DOE, DOC, and the Department of Defense have issued or are in the process of issuing departmental or agency strategies or policies on environmental technology. In some cases, these strategies are part of broader efforts to more clearly define departmental missions and goals. (See subsequent chapters about specific agency activities for details).

SOURCE: Office of Technology Assessment, 1995

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[1]National Science and Technology Council, *Bridge to* a *Sustainable Future National Environmental Technology Strategy* (Washington, DC: U.S. Government Printing Office, April 1995).

[2]In addition, federal agencies have been working to identify specific R&D actions through a subgroup of two NSTC committees, called the Joint Subcommittee on Environmental Technologies (JSET). In December 1994, JSET issued a draft Strategy and Implementation Plan for Environmental Technologies for public comment. The draft identifies 12 environmental challenges, and federal agency actions that could be taken in the next five years that would contribute to meeting those challenges The challenges are considered crosscutting, in the sense that several agencies and disciplines could be required to address them effectively The draft IS now being recast.

cies themselves and with the private sector. These mechanisms are discussed briefly below.

National Science and Technology Council (NSTC)

The Clinton Administration has sought to coordinate interagency activities and strategy development for environmental technology through the National Science and Technology Council. Set up in November 1993, NSTC is the highest level science and technology coordinating mechanism for federal agencies. It replaced the federal Coordinating Council on Science, Engineering, and Technology used by the Bush Administration. The Council, chaired by President Clinton, consists of the heads of major departments and agencies with responsibilities for science and technology; a key purpose of NSTC is to set goals for federal R&D funding. The Office of Science and Technology Policy assists NSTC.

Within NSTC, environmental technology responsibilities are carried out through two subgroups, the Committee on Environment and Natural Resources (R&D issues) and the Committee on Civilian Industrial Technology (environmental technology use by U.S. industry and exports of environmental technology). A Joint Subcommittee on Environmental Technology (JSET), formed to address areas of mutual interest between the two committees, has been working to help establish a federal agency R&D agenda for environmental technology. Increasingly, a working group on environmental technology with broader representation than these two committees has assumed JSET functions.

Several coordination and outreach activities are carried out under the overall NSTC framework, including:

Interagency Environmental Technologies Office (IETO): This working office within NSTC is intended to help achieve cooperation, coordination, and collaboration among the many federal committees, programs, and activities related to environmental technology. IETO was set up to facilitate collaboration by DoD, DOE , and other agencies on projects of mutual interest. IETO's scope includes all environmental technology issues (remediation, restoration, pollution prevention, control and monitoring) and any federal agency involved in technology development can participate. (IETO depends on agency members for funds and personnel). IETO also serves as an information clearinghouse and focal point for collaboration with the private sector, the states, and local governments for advancing environmental technologies. An information system, called the Global Network for Environmental Technology (GNET), has been set up to facilitate this interaction.

The Rapid Commercialization Initiative (RCI): This interagency initiative, announced in December 1994, seeks to advance the commercialization of environmental technologies to further both environmental and economic objectives. Under this effort, which will be coordinated by IETO and the Department of Commerce, federal agencies will help technology sponsors find test or demonstration sites, support technology performance verifications, and work with states on expediting permitting procedures (such as interstate reciprocity) that could speed use of these technologies. The RCI will focus on technologies that respond to private sector, as well as public sector, needs. The RCI will rely on existing federal agency programs that support environmental technology demonstration, verification, and diffusion. For example, these agencies may seek to increase the availability of testing sites and experimental permits to make it easier for developers to bring their technologies to market more easily. It will also seek to verify the performance of innovative technologies so that regulators and potential clients can assess their efficacy.

Private Enterprise-Government Interaction Task Force (PEGI): PEGI conducts outreach to identify research interests common to both the private sector and government research organizations. It now functions as an interagency task group of NSTC's Committee on Environment and Natural Resources. It works to identify private sector R&D on environment and natural resources and to inform the private sector of related govern-

ment-sponsored R&D. To do this, PEGI holds periodic meetings and an annual public roundtable conference.

Comprised of representatives from nine federal agencies, PEGI does not have funding of its own, and must rely on its member agencies to plan and hold meetings. PEGI has helped form several partnerships with private entities, including one dealing with offshore petroleum platform use for scientific research and another in the bioremediation area. PEGI also is sponsoring a government-wide Private Sector Fellowship Program. Firms and associations can sponsor staff members to work with managers of various federal environmental programs as a way to foster interactions and collaborative efforts between industry and the federal government.

Other NSTC Programs: NSTC also has become a coordinating body for crosscutting R&D programs that involve several agencies. For example, the global change research program, although primarily an environmental research (not technology) activity, involves 11 federal agencies or departments. NASA accounts for half or more of the overall spending on global change research, which exceeded $2 billion in FY 1995.

Some other multiagency R&D programs that are coordinated through the NSTC also have a significant environmental content, such as the Partnership for a New Generation of Vehicles (PNGV).[8] This partnership includes seven federal agencies (DOE, DoD, DOC, the Department of Transportation, NASA, NSF and EPA) and the U.S. Council for Automotive Research, which represents Chrysler, Ford, and General Motors. The federal agencies plan to commit an estimated $246 million on PNGV in FY 1995.

In addition, several interagency working groups have been set up to address specific issues that may involve environmental technology. One of the longest standing of these is the federal Remediation Technologies Roundtable. The roundtable is composed of representatives from several federal agencies that meet semi-annually to discuss new technology for treatment and remediation of hazardous wastes, and sponsor publications about field demonstrations of innovative treatment technologies[9] and access to data bases for cleanup technologies.[10]

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[8]PNGV's has three primary goals: 1) to improve the productivity of U.S. manufacturing by upgrading U.S. manufacturing technology while reducing the environmental impacts and improving quality; 2) to pursue advances in vehicles that can lead to improvements in fuel efficiency and emissions of standard vehicle designs, while pursuing safety advances to maintain safety performance; and 3) to develop a vehicle to achieve up to three times the fuel efficiency of today's comparable family vehicle with an equivalent purchase price.

[9]*Synopses of Federal Demonstrations of Innovative Site Remediation Technologies*, Third Edition, EPA/542/B-93/009 (Washington, DC: U.S. Government Printing Office, October 1993).

[10]*Accessing Federal Data Bases for Contaminated Site Clean-up Technologies*, Second Edition, EPA/542/B-92/002 (Washington, DC: U.S. Government Printing Office, August 1992).

Department of Energy 3

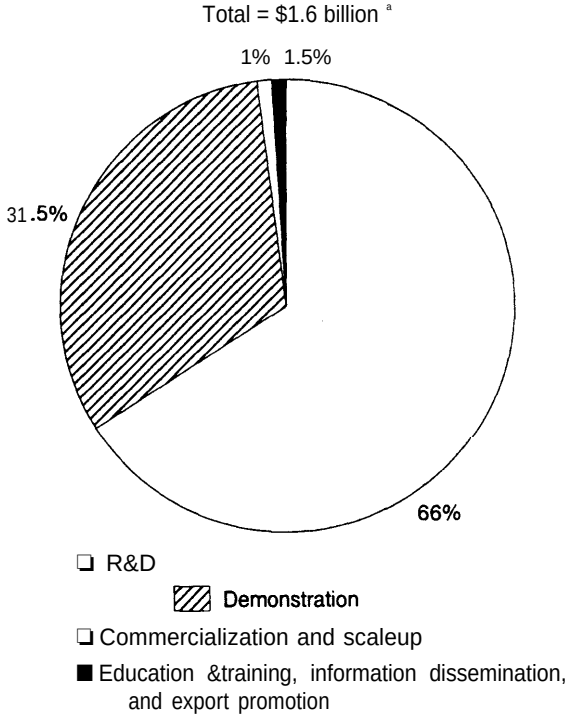
The Department of Energy (DOE) is both a major user and developer of environmental technologies. DOE supports research and development on technologies that allow energy to be produced, generated, transmitted, and used in cleaner ways. According to Clinton Administration data, it accounts for nearly three-fourths of federal agency spending on so called "avoidance technologies." DOE also administers the world's largest environmental restoration and management program to address contamination and waste management problems at its nuclear weapons research and production facilities.[1] Part of the cleanup and waste management budget supports development of specialized or potentially more cost-effective technologies to meet DOE's own cleanup and waste management needs.

Estimates of DOE's environmental technology spending in FY 1994 range from about $1 billion to $1.6 billion (depending on the definition of environmental technology). (See tables 2-1 and 2-2 in chapter 2). This is by far the largest of any federal agency and reflects the multiple dimensions of DOE's involvement in this R&D, from in-house cleanup to encouraging energy conservation.[2] DOE's energy and environmental technol-

[1] On the size of DOE's program, see Secretary of Energy Advisory Board, Task Force on Alternative Futures for the Department of Energy National Laboratories, *Alternative Futures for the Department of Energy National Laboratories*, (Washington, DC: February 1995). For discussion of DOE environmental problems, see U.S. Congress, Office of Technology Assessment, *Complex Clean Up: The Environmental Legacy of Nuclear Weapons Production*, OTA-O-484 (Washington, DC: U.S. Government Printing Office, February 1991).

[2] U.S. Congress, Office of Technology Assessment, *Industry, Technology, and the Environment: Competitive Challenges and Business Opportunities*, OTA-ISC-586 (Washington, DC: U.S. Government Printing Office, January 1994).

FIGURE 3-1: DOE Environmental Technology Budget by Function, FY 1994



[a]Total is based on NSTC data displayed in table 2-1 in chapter 2.

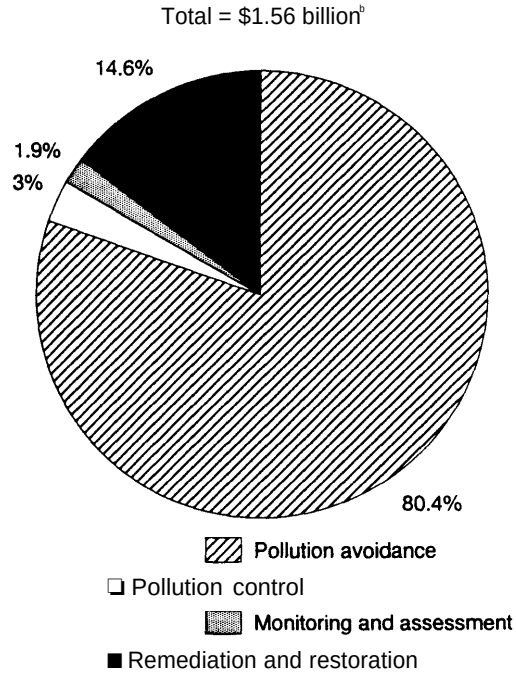
SOURCE: National Science and Technology Council (NSTC), Committee on Environment and Natural Resources (CENR), unpublished tables, 1994.

ogy activities in some instances cover the entire spectrum from basic research, through applied research and development, demonstration, testing and evaluation, to procurement, technical assistance, and export promotion. (See figures 3-1 and 3-2). However, most of the funds are spent on research, development, and demonstration (RD&D).

A sizable portion of DOE's research and development (R&D) is undertaken by the DOE laboratories, some of which are government operated and some of which are operated by contractors to DOE. DOE also supports environmental technology R&D by others, through grants, cooperative agreements, and other arrangements with industry, other private organizations, universities and other governmental bodies.

DOE's environmental technology R&D takes place in a broader context of intense debate about DOE's mission, both in Congress and the executive branch.[3] In February 1995, Secretary of Energy Hazel R. O'Leary pledged a $14.4 billion reduction in DOE's budget over the next five

FIGURE 3-2: Allocation of DOE Environmental Technology RD&D and Scaleup by Category,[a] FY 1994 (in percent)



[a]Proportions are based on National Science and Technology Council data on research and development, demonstrations, and scaleup, displayed in table 2-1 in chapter 2.
[b]Total is based on data displayed in table 2-1 in chapter 2.

SOURCE: National Science and Technology Council, unpublished data Apr. 6, 1995.

[3]Congress was in the process of considering Department of Energy appropriations for FY 1996 as this report went to press. The House Committee on Appropriations had just reported two bilk H.R. 1905 and H.R. 1977, pertaining to DOE R&D programs. House action was imminent.

years—a 17-percent reduction in DOE's budget over the period. Some in Congress have proposed elimination of DOE, with some of its functions distributed elsewhere within the government, and others either eliminated or privatized. Discussion also is underway about the mission of the DOE laboratories, especially the nine multiprogram national laboratories set up originally to develop nuclear weapons and energy. Several recent reports, such as by the so called Galvin Commission[4] and by the U.S. General Accounting Office (GAO)[5], have discussed options for revamping these laboratories, including their environmental R&D functions.

Environmental technology activities within DOE are carried out by several offices under several assistant secretaries. The Assistant Secretary for Energy Efficiency and Renewable Energy oversees energy related environmental technology development pertaining to industry, utilities, buildings, and transportation. The Assistant Secretary for Fossil Energy oversees DOE support for fossil energy R&D, some of which could lead to cleaner or more efficient production and use of fossil fuels. Cleanup and restoration are the responsibility of the Assistant Secretary for Environmental Management. The Assistant Secretary for Environment, Safety and Health has responsibility for assuring environmental integrity on DOE lands and facilities, and protecting the health and safety of DOE employees and citizens living near DOE facilities.

The discussion below focuses on selected DOE RD&D programs related to environmental technologies: environmental management and restoration, fossil fuel, energy efficiency, solar and renewable energy, and some other programs. The chapter appendix briefly discusses the role of DOE laboratories in environmental technology R&D, and mechanisms, such as cooperative research and development agreements (CRADAs), by which they carryout R&D with industry. However, activities of individual DOE laboratories are not discussed in detail. Other aspects of DOE's environmental technology activities, such as its role in technology transfer (aside from CRADAs), technical assistance, and energy and environmental technology export promotion also are not discussed in detail.[6]

ENVIRONMENTAL MANAGEMENT AT DOE FACILITIES

The Environmental Management (EM) program is responsible for identifying and reducing risks, and managing and treating nuclear and hazardous waste (and mixtures of radioactive and hazardous wastes) generated over the last half century at 137 DOE sites and facilities in 34 states and territories where nuclear energy or weapons research and production has been conducted.[7] EM's budget for waste management, cleanup, and other activities has grown from $ 1.7 billion when the program was set up in 1989 to roughly $6 billion in FY 1994.[8] Most of the budget covers direct costs for

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[4] Report by the Secretary of Energy Advisory Board, Task Force on Alternative Futures for the Department of Energy National Laboratories, op cit., footnote 1.

[5] See U.S. General Accounting Office, *Department of Energy: National Laboratories Need Clearer Missions and Better Management*, GAO/RCED-95-10 (Washington, DC: U.S. Government Printing Office, Jan. 27, 1995).

[6] For discussion of export promotion programs and environmental technology, see *Industry, Technology, and the Environment*, op. cit., footnote 2, pp. 151-181, and U.S. Congress, Office of Technology Assessment, *Development Assistance, Export Promotion, and Environmental Technology*, OTA-BP-ITE-107 (Washington, DC: U.S. Government Printing Office, August 1993).

[7] For perspective on the environmental management program, see U.S. Congress, Office of Technology Assessment, *Complex Clean Up: The Environmental Legacy of Nuclear Weapons Production*, OTA-O-484 (Washington, DC: U.S. Government Printing Office, February 1991), especially pp. 23-74.

[8] Department of Energy, *Environmental Management, 1995: Progress and Plans of the Environmental Management Program*, DOE/EM-0228 (Washington, DC: U.S. Department of Energy, 1995, p. 64).

TABLE 3-1: Environmental Management (EM) Technology Development Budget[a] ($ millions)

Subactivity	FY 1994 (actual)	FY 1995 (adjusted)[b]	FY 1996 proposal Clinton Administration
Treatment and remediation technologies	166.5	148.5	203.8
Innovative and crosscutting technology	81.5	80.2	80.2
Industry programs	26.3	42.8	41.2
Technology integration	18.6	9.7	17.0
Program support	37.2	32.2	33.3
Program direction	14.9	13.4	**15.0**
Education and integrated risk management initiative	21.5	39.2	0
Infrastructure program	27.2	32.8	0
Total	**393.8**	**398.8**[c]	**390.5**[c,d]

[a]Figures cited are program expenditures; these estimates are not comparable with estimates of RD&D activities in tables 2-1 and 2-2 in chapter 2. Figures may not add due to rounding.
[b]Figures adjusted to take into account FY 1995 rescissions in the EM program under Public Law 104-6.
[c]Education and integrated risk management and infrastructure have been transfered to other programs for FY 1996. Hence, the baseline budget for FY 1995 would not include these programs.
[d]The House Committee on Appropriations, in House Report 104-149, recommends $380.5 million for the program in FY 1996.

SOURCE: Department of Energy, 1995.

waste management and environmental restoration required of DOE under its more than 100 compliance agreements with states or other parties, or to comply with environmental regulations.[9] However, a small portion of the total (roughly 6 to 8 percent per year) has been allocated to new and innovative technology development. As the overall program has grown, the technology development component has grown from $183 million to $394 million in 1994 (see table 3-l). The estimated technology development budget for FY 1995 is $399 million (adjusted for rescissions made under Public Law 104-6).

The goals of the technology development program are to reduce risks to people and the environment, reduce cleanup costs, and find new technologies for environmental problems for which current solutions do not exist.[10] DOE has established five focus areas for EM technology development: [11]

- mixed waste characterization, treatment and disposal,
- radioactive tank waste remediation,
- contaminant plume containment and remediation,
- landfill stabilization, and
- facility deactivation and disposition.

Much of the EM technology program is carried out by DOE laboratories. However, a portion of the funds ($43 million in FY 1995) supports private sector or university RD&D on high-risk, potentially high payoff technologies that did not originate within DOE. The intent is to support the competitiveness of the U.S. environmental industry in its effort to develop commercially viable technologies broadly applicable to EM's mission.

The EM budget listed as technology integration in table 3-1 supports activities to demonstrate and test technologies under different field condi-

[9]Department of Energy, *Fiscal Year 1996 Congressional Budget Request, vol. 5, Environmental Management,* Washington, DC, February 1995, p. 29.

[10]Statement of R. J. Guimond, Rear Admiral, Principal Deputy Assistant Secretary for Environmental Management, Department of Energy, before the Subcommittee on Energy and Enviromnent, Committee on Science, House of Representatives, U.S. Congress, Washington, DC, Feb. 14, 1995, p. 33.

[11]Ibid., p. 15

tions and to evaluate the regulatory and marketing acceptability of these technologies. This is often done through contracts, subcontracts, or CRADAs with industry and universities. The technology integration budget also supports activities carried out by the Committee to Develop On Site Innovative Technologies (the so called DOIT Committee), comprised of key federal agencies and the Western Governors Association.

DOE has been criticized by the GAO and others for failing to see that innovative technologies demonstrated through the technology development program are used in the field in cleanup operations. Recently, DOE has made some management changes aimed at encouraging greater use of innovations. However, the technology development office still is not involved in some key decision points in selecting technology to be used for clean up. [12]

The size of the EM program as a whole could decline in the coming years. Secretary O'Leary says that the costs of the EM program will be reduced by $4.4 billion from what they would otherwise be over five years.[13] While productivity improvements are expected to cover part of the difference, some DOE projections show a gap between EM program resources and responsibilities.[14] The role of environmental technology development in a more resource constrained EM program is an important issue. In theory, technology development could lead to productivity gains that could reduce remediation costs, make cleanup practical on more sites, and improve the efficiency of waste management operations. It also could help reduce risks to workers, nearby communities, and the environment. However, other management options, such as adjusting cleanup demands to anticipated future landuse, could also be pursued.

FOSSIL ENERGY R&D PROGRAMS

The R&D component of the Fossil Energy program supports fundamental research and technology development related to production and use of natural gas, oil, coal and other fossil fuels. The purpose is to strengthen the technology base that can be tapped by industry as it develops new products and processes for the market. Part of this R&D is conducted through cost-sharing partnerships with industry, or grants to universities and other entities. Activities supported range from university and national laboratory based basic research to proofs of concepts by private firms. An objective of much of this R&D is to develop cleaner or lower environmental impact technologies for fossil fuel supply, conversion, delivery or use. Examples include R&D for advanced gas turbines and various cleaner coal technologies. Substantial fuel cell R&D is also administered under this program. The stated rationales for this fossil fuel R&D are to benefit the nation through lower energy costs, reduced environmental impact, increased technology exports, and reduced dependence on insecure energy sources.

The total R&D component of the Fossil Fuel program amounted to $426 million in FY 1994 and an estimated $442 million in FY 1995. Funding for the program is likely to fall appreciably in FY 1996.[15]

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[12] U.S. General Accounting Office, *Department of Energy: Management Changes Needed to Expand Use of Innovative Cleanup Technologies*, GAO/RCED-94-205 (Washington, DC: U.S. Government Printing Office, August 1994).

[13] The Clinton Administration's budget proposal for FY 1996 sought an increase in the EM appropriation for FY 1996; however, this reflects EM taking on added responsibilities at several high-risk DoD program sites, including the Savannah River site in South Carolina. *Fiscal Year 1996 Congressional Budget Request, vol. 5*, op. cit., footnote 8, p.4.

[14] Environmental Management, 1995, op cit., footnote 7, p. iii.

[15] The magnitude of the reductions was still uncertain in June 1995, as this paper went to press. A DOE authorization bill was under consideration by the House Committee on Science. Its Subcommittee on Energy and Environment had just acted on a proposal, subsequently introduced as H.R. 1816, which would authorize $204 million in FY 1996 appropriations for fossil fuel R&D. The House Committee on Appropriations recommended a higher level—$384.4 million for the programs for FY 1996, but stated an intention to reduce funding for this activity by 10 percent each year over the next four years, noting that this gradual reduction would reach a future level more in line with that proposed by the authorizing committee. (The Clinton Administration initially sought $437 million for these programs in its FY 1996 budget proposal).

TABLE 3-2: Selected Components of DOE's Fossil Fuel R&D Budget[a] ($ millions)

			FY 1996 proposals		
	FY 1994 (actual)	FY 1995[b] (estimate)	Clinton Administration	Mark by House Subcommittee on Energy and Environment	House Committee on Appropriations Recommendation
Coal	41.0	38.5	16.6	5.3	23.8
Advanced clean fuels	96.1	90.5	73,4	23.7	79.8
Advanced clean and efficient power systems	28.8	25.4	25.4	21.0	22.7
Advanced research and technology development					
Gas	43.7	66.7	90.4	26.4	60.3
Natural gas	51,1	49.6	55.5	31.5	53.5
Fuel cells					
Oil technology	74.3	81.7	86.8	41.2	63.8
Other	91.1	89.4	88.6	54.9	80.7
Total	**426.0**	**441.8**	**436.5**	**204.0**	**384.5**

[a]Figures cited are program expenditures; these estimates are not comparable with estimates of RD&D activities in tables 2-1 and 2-2 in chapter 2. Only part of the program expenditures listed above are for environmental technology
[b]Estimates do not reflect possible rescissions proposed for FY 1995.
[c]Subcommittee of Committee on Science.

SOURCE: Department of Energy, 1995; Subcommittee on Energy and Environment, Committee on Science, House of Representatives, U.S. Congress, "Chairman's Mark, U.S. Department of Energy, FY 1996 Authorization," June 8, 1995; Committee on Appropriations, House of Representatives. U.S. Congress, *Department of Interior and Related Agencies Appropriations Bill, 1996,* House Report 104-173, June 30, 1995.

Table 3-2 shows components of the program, and how these activities are allocated among different fuels. Only a portion of these funds should be considered environmental technology RD&D. DOE identified $314 million in fossil fuel projects as focused environmental technology activities in the data it submitted to the interagency Committee on Environment and Natural Resources (CENR). (See chapter 2 for discussion of CENR data).

A separate activity, the Clean Coal Technology Program, has been underway for 10 years. The program has cost-shared 45 demonstrations with industry, and entailed $2.3 billion in federal funds since its inception. (Total public and private spending on the demonstrations is estimated to be $6.9 billion; provisions exist for recouping government funds if technology is commercialized). Six of these demonstrations have been completed; another 24 are expected to be completed by the end of FY 1996, according to the Clinton Administration. As suggested by the figures in table 3-3, support for this forward funded program is being phased down.[16]

ENERGY EFFICIENCY PROGRAMS

DOE's energy efficiency activities fall out under four broad end-use areas-transportation, utilities, buildings, and industry. Offices exist for each of these areas, as well as a crosscutting national program office. As with several DOE programs, a full range of activities, including basic and applied research, demonstration projects, technical assistance, and evaluations, may be supported. Most of the projects are conducted with industry participants, who typically pick up one-third to one-half of the costs.

[16]Due to a combination of prior appropriations and rescissions in Public Law 104-6,$150 million in budget authority would be available for obligation in FY 1996 under the Clean Coal Program. The Clinton Administration initially sought $45 million for the program in FY 1996 but subsequently amended the request to about $10 million. H.R. 1816 (as introduced) would not authorize FY 1996 appropriations to be used for the program. The House Appropriations Committee recommended no new budget authorization for the program in FY 1996, noting that, with the rescission. $150 million would be available in FY 1996.

TABLE 3-3: Clean Coal Technology Program ($ millions)

			FY 1996 proposals		
	FY 1994 (actual)	FY 1995 (estimate)	Clinton Administration [b]	H.R. 1816 (as introduced)	House Committee on Appropriations Recommendations
Clean Coal Technology Program	221.5	37.1	10.0	0	**No** new budget authority

[a]The Clean Coal Program IS forward funded Advance appropriations of $200 million had been made available for obligation in FY 1996 in prior appropriations acts However, Public Law 104-6 rescinded $50 million from funds available for obligation in FY 1996 Hence the total available for obligation in FY 1996 IS$150 million.
[b]The administration originally sought $45 million for the program.

SOURCE: Department of Energy, 1995; H.R. 1816 (as Introduced); Committee on Appropriations, House of Representatives, U.S. Congress, *Department of Interior and Related Agencies Appropriations Bill,* 1996, House Report 104-173, June 30, 1995.

While primarily concerned with energy conservation, much of the R&D supported by these offices can lead to technologies that produce important environmental benefits due to reduced energy use and associated pollution. Whether to call these technologies energy or environmental technologies is often arbitrary. For example, the Industrial Waste Reduction Program carried out by DOE's Office of Industrial Technologies (OIT) is one of the largest sources of federal funds for industrial pollution prevention R&D.

In some cases. R&D conducted by the energy efficiency programs contributes to multiagency initiatives, such as the Partnership to a New Generation of Vehicles (PNGV) and the Climate Change Action Plan (CAP). Funding for all energy efficiency R&D (excluding technical assistance) under the four end-use offices programs was $388 million in FY 1994. (See table 3-4). Most of this ($334 million) was for activities that supported PNGV or CAP objectives, or was identified as focused environmental technology R&D by the CENR.

While the Clinton Administration sought major increases for these activities in its FY 1996 budget proposal, Congress is considering significant reductions. H.R. 1816, for example, would authorize $206 million for the programs in FY 1996.

Transportation Technology: Environmentally pertinent R&D supported by DOE's Office of Transportation Technologies includes technologies focused on clean-car and electric-vehicle-related programs. DOE is a major participant in the Clinton Administration's Partnership for a New Generation of Vehicles, which is coordinated through the National Science and Technology Council discussed in chapter 1. The transportation office supports, among other things, R&D for increasing fuel efficiency, development of electric and hybrid propulsion and battery systems, and advanced fuel cell technologies. DOE identified about $165 million in such activities for FY 1994.

Building Technology: Building technology related to environmental issues is mainly concerned with energy conservation. Many of the activities supported through this office contribute to objectives of the Global Change Action Plan. Some building technology programs support R&D toreduce use of, or find alternatives for, chlorofluorocarbons (CFCs) in making building materials, and in refrigeration systems and air conditioning. CFC use is being phased out under an international agreement, as these substances contribute to ozone depletion in the stratosphere.

Utility Technologies: Among other things, DOE's Office of Utility Technologies supports a range of renewable energy alternatives, such as solar, wind, geothermal, ocean-based, hydroelectric, biomass, and photovoltaic alternatives to fossil fuel produced power. These are discussed in the next section.

Industrial Technologies: The goal of OIT's Industrial Waste Reduction Program (IWRP) is to "improve the energy efficiency and competitiveness of private industry through cost-effective waste material reduction." IWRP focuses on the highly polluting processing industries, including

TABLE 3-4: Energy Conservation Research and Development—Selected Activities[a,b] ($ millions)

			FY 1996 proposals		
	FY 1994 (actual)	FY 1995[c] (estimate)	Clinton Administration	H.R. 1816 (as introduced)	House Committee on Appropriations Recommendations
Building technology	80.7	115.6	154.8	40,1	92.7
Industrial technology	123.9	135.2	172.9	51.1	110.7
Transportation technology	176.9	206.3	262.3	106.7	177,1
Utility technology	6.7	8.8	9.9	0	0
Policy and management	4.7	8.3	11.3	0	7,7
Total	392.9	474.2	611.2	198.0	388.4

[a]Figures cited do not include technical and financial assistance
[b]Figures cited are program expenditures, these estimates are not comparable with estimates of RD&D activities in tables 2-1 and 2-2 in chapter 2. Only part of the program expenditures are for environmental technology R&D.
[c]Some portion of the total may be subject to rescission.

SOURCE: Department of Energy; H.R. 1816 (as introduced); Committee on Appropriations, House of Representatives, U.S. Congress, *Department of Interior and Related Agencies Appropriations Bill, 1996,* House Report 104-173, June 30, 1995.

pulp and paper, oil refining, chemicals, steel, aluminum, foundries, and glass. These industries are major users of energy and their operations often produce significant environmental impacts. The costs of projects are usually shared with private companies or industry trade associations. IRWP activities fall under five categories: waste characterization, opportunity assessments, institutional analysis, technology research and development, and technology and information transfer. Data prepared for the CENR shows about $90 million was spent on focused environmental technology R&D under this program in FY 1994.

OIT is undertaking the Industry of the Future project,[17] which seeks to augment energy, economic. and environmental benefits from government technology investments. Several industry-led efforts to articulate long-term technology needs are underway; the industries involved are energy and pollution intensive.

Another OIT activity is the National Industrial Competitiveness through Energy, Environment and Economics (NICE[3]) Program, which is jointly managed with EPA. Begun in 1990, the program provides small research grants for technology development that would simultaneously conserve energy, reduce waste and pollution, and improve competitiveness. NICE[3] seeks to involve industry in developing such process modifications. Another purpose is to promote coordination and cooperation among EPA, DOE, and government offices at the state, regional, and federal level. OIT maintains that industry contributes four dollars to the program for every dollar contributed by DOE. [18]

A recent DOE report claims that successfully commercialized OIT technologies have produced cumulative energy savings of $2.2 billion, and have also reduced industrial emissions of particulate, sulfur dioxide, carbon dioxide, and volatile organic compounds. [19]

SOLAR AND RENEWABLE ENERGY

Funding for all DOE solar and renewable energy activities was $324 million in FY 1994 (see table 3-5). The lion's share went to solar energy, which

[17] Office of Industrial Technologies, Department of Energy, *Industries of the Future, Energy Efficiency for Our Sustainable Future,* Washington, DC, September 1994.

[18] Ibid., p. 16.

[19] As indicated in Department of Energy, Office of Energy Efficiency and Renewable Energy, *Technology Partnerships: Enhancing the Competitiveness, Efficiency, and Environmental Quality of American Industry* (Springfield, VA: National Technical Information Service, April 1995), pp. 5-16.

TABLE 3-5: DOE Solar and Renewable Energy Program—Selected Activities[a] ($ millions)

			FY 1996 proposals	
	FY1994 (actual)	FY1995[b] (estimate)	Clinton Administration	House Committee on Appropriations Recommendation[c]
Solar energy	$242.3	$292.2	$326.4	$149.2
Geothermal	23.0	37.8	37.0	25.7
Hydroelectric systems	1.0	4.8	1.0	0
Hydrogen research	9.6	9.6	7.3	15.
Electric energy systems and storage	44.2	44.4	46.9	28.9
Policy and management	3.7	4.8	4.8	2.8[d]
Total	323.8	393.6	423.4	221.6

[a]Figures cited do not include In-house energy management. Figures are program expenditures; these estimates are not comparable with estimates of RD&D activities in tables 2-1 and 2-2 in chapter 2. Only part of the program expenditures are for environmental technology R&D
[b]Figures may be affected by rescission.
[c]As Indicated in H.R. 1905 (as reported) and House Report 104-149
[d]This figure does not include an earmark of $44.8 million in energy supply R&D funds for the innovative Renewable Energy Technology Transfer Program authorized by section 1211 of The Energy Policy Act of 1992 (42 U.S.C. 13316). The earmark was added by the t-louse during the debate on H.R. 1905.

SOURCE: Department of Energy, 1995; *Inside Energy/With Federal Lands* (weekly newsletter) (New York, NY: McGraw Hill, June 19, 1995).

includes photovoltaics, solar thermal, biofuels, and wind energy. The remainder was distributed among programs for geothermal energy, hydroelectric research, hydrogen, and electric energy systems and storage. Depending on the program, these funds were used to support a broad spectrum of activities, ranging from basic research, development and demonstrations, to field testing and evaluation in cooperation with industry, to support for technical assistance and export promotion. The CENR data on focused projects identified $177 million in solar and $43 million in other renewable energy environmental technology projects in FY 1994; environmental technology was a contributing factor in other projects as well.

DOE's objectives for the solar and renewable programs include contributions to national energy security, enhancement of worldwide sales of U.S. energy products, improvement of industrial competitiveness, and technology transfer. In many cases, solar and renewable applications also could have environmental benefits.

Much of the R&D is carried out through the National Renewable Energy Research Laboratory and other DOE laboratories, including Sandia and Los Alamos. These laboratories also have longstanding programs. DOE's Office of Utility Technologies (described earlier) and other sector offices administer programs. Many of the activities are carried out in close cooperation with industry.

Funding for solar and renewable energy R&D is likely to be scaled back appreciably in FY 1996 (see table 3-5).

OTHER PROGRAMS

Office of Energy Research: Some of the research supported by this office on global change, modeling of environmental and energy systems, bioremediation, hazardous wastes and other subjects is pertinent to environmental technology. CENR identified $176 million of the office's budget as focused R&D on environmental technology. However, much of this supports modeling global change, which is not considered environmental technology R&D in this paper.

Bioremediation Environmental Technology Partnerships: Bioremediation uses microorganisms or other living organisms to transform waste products into less harmful substances. The Clinton Administration seeks $6 million to launch this cooperative program with industry. The purpose will be to field test microorganisms already identified as useful in bioremediation, and to identify

and manipulate other microorganisms thought capable of transforming other contaminants. Two research sites suitable for long-term evaluation of bioremediation strategies would be selected. The program would be carried out in DOE's Biological and Environmental Research Program.

Inventions and Innovations programs: Administered by the Office of National Programs under the Assistant Secretary for Energy Efficiency, DOE's inventions and innovations programs focuses on independent inventors and small businesses. In addition to grants to help develop promising inventions and innovations, the programs also conduct commercialization workshops and training sessions, and help showcase technologies through fairs and publications.

Other DOE programs may from time to time support environmental technology R&D or other related activities. In addition, DOE is a major participant in several interagency activities concerning environmental technology, including the Interagency Environmental Technologies Office.

APPENDIX 3-1: ROLE OF THE DOE NATIONAL LABORATORIES

The Department of Energy (DOE) laboratories conduct mission oriented research and development (R&D) in areas considered to serve U.S. national interests. The laboratories have traditionally emphasized defense and energy related research including nuclear weapons and atomic energy R&D, alternative energies, and other work related to national security. In FY 1994, DOE spent approximately $6.6 billion on R&D. Of that total, $3.8 billion (58 percent) was spent on R&D conducted at the National Laboratories.[20] Other federal agencies, such as the Department of Defense, also fund research at the Laboratories. The Laboratories' research covers a broad spectrum of basic sciences and applied technologies, including environmental technology related R&D.[21]

The DOE laboratories include the large multiprogram laboratories, and many smaller single-program laboratories supported by DOE. The multiprogram laboratories are all government-owned, contractor-operated (GOCO) facilities that conduct research on many different topics. These laboratories are Argonne National Laboratory, Brookhaven National Laboratory, Idaho National Engineering Laboratory, Lawrence Berkeley Laboratory, Lawrence Livermore National Laboratory, Los Alamos National Laboratory, Oak Ridge National Laboratory, Pacific Northwest Laboratory, and Sandia National Laboratories. As large multiprogram facilities, with budgets exceeding $1 billion in many cases, most of these laboratories perform some energy efficiency or environmental technology related R&D.

In addition to the multiprogram GOCO laboratories, DOE supports several single-program research facilities that perform energy and environmental technology R&D. Some of these National Laboratories are government-owned and government-operated (GOGO), while others are operated by contractors. The largest of the single-program laboratories performing energy and environmental research are:

- Morgantown Energy Technology Center, a GOGO laboratory,
- National Renewable Energy Laboratory, a GOCO laboratory,
- Pittsburgh Energy Technology Center, a GOGO laboratory,

[20] National Science Foundation, *Federal Funds for Research and Development: Fiscal Years 1992, 1993, and 1994*, volume 42 (Washington, DC: 1994).

[21] Department of Energy, *Technology Transfer 92/93* (Washington, DC: U.S. Government Printing Office, 1992).

- Savannah River Technology Center, a GOCO laboratory, and
- Westinghouse Hanford Company, a GOCO laboratory.[22]

Technology transfer and cooperative research have become increasingly important activities at the DOE laboratories.[23] Several mechanisms exist for DOE to interact with the private sector, including:

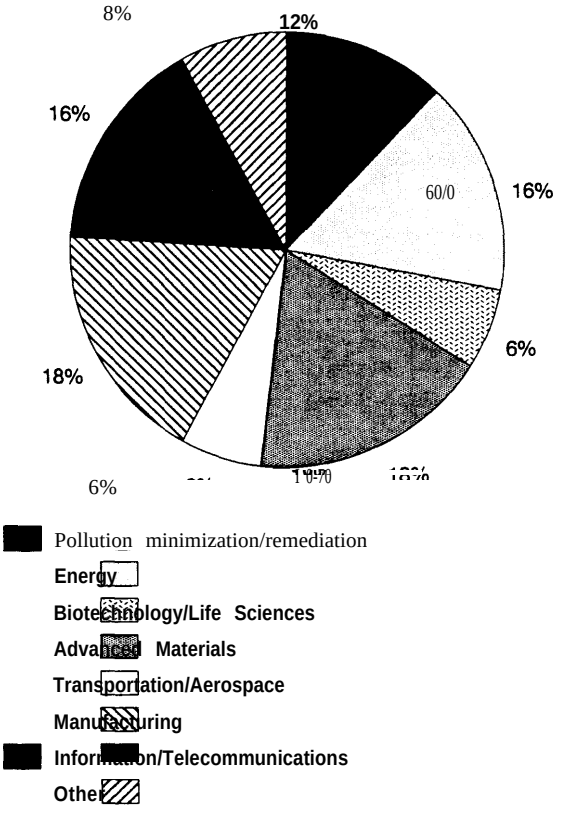
- cost-shared contracts and subcontracts,
- cooperative research and development agreements,
- reimbursable work for others agreements,
- technical assistance agreements,
- scientific personnel exchanges,
- materials transfer agreements,
- software licenses, and
- government patent licensing agreements.

One method of interaction is through cooperative research and development agreements. About 12 percent of CRADAs at the National Laboratories pertain to pollution prevention and remediation (see figure 3-3); in addition, many CRADAs categorized in other areas, such as transportation and energy, may have environmental components.

As defined and authorized by law, a CRADA is an agreement between one or more federal laboratories and one or more nonfederal parties, under which the government laboratory provides personnel, services, facilities, equipment. or other resources (but not funds), and the nonfederal parties provide funds, personnel, services. facilities, equipment, or other resources toward the conduct of specific research or development efforts (15 U.S.C. 3710a[d][l]). CRADA research projects, which usually are conducted in partnership with a company or consortium of companies, need to be consistent with the central mission of the laboratory.

In some cases, the companies come out of CRADAs with rights to keep laboratory notebooks, and information can be protected from

FIGURE 3-3: Distribution of 1995 CRADAs by Kind of Technologies



SOURCE: M. Chalhoub, "Pubic-Prwate Partnerships through Cooperative Research and Development Agreements Role of the National Labs in Commercializing Environmental Technologies," contract document prepared for the Office of Technology Assessment, U.S. Congress, Washington, DC, 1995.

[22] Ibid.

[23] Under the Stevenson-Wydler Technology Transfer Act of 1980 (Public Law 96-480), Federal Technology Transfer Act of 1986 (Public Law 99-502), and National Competitiveness Technology Transfer Act of 1989 (Public Law 101-1 89) the large multiprogram GOCO National Laboratories have been authorized and encouraged to transfer technology to the private sector. L. Rudolph. "Review of Federal Technology Transfer Law and Implementation by federal Agencies," *Federally Funded Genome Research: Science and Technology Transfer Issues, Proceedings* of a Public Meeting, May 21, 1992. Genome Patent Working Group, Committee on Life Sciences, Federal Coordinating Council for Science, Engineering, and Technology. Office of Science and Technology Policy (Washington, DC: U.S. Government Printing Office, 1992).

general dissemination for up to five years.[24] The federal government retains nonexclusive royalty-free worldwide rights to CRADA inventions and discoveries, including the right to have products manufactured by another company for the government's use.

DOE CRADAs have grown at a relatively faster pace over fewer years than CRADAs at other federal research institutions, according to an OTA contractor sample of CRADAs at several federal research agencies.[25] In April 1991, DOE had 12 CRADAs at its laboratories. As of January 1995, DOE CRADAs have grown to a total of 1,157 ongoing CRADAs, including 152 identified as environmental technology R&D.[26] Many other CRADAs on other research topics may have an environmental component as well.

DOE supports environmental research through both the Energy Research Program (ER) and the Defense Program (DP) at the National Laboratories. Some DP laboratories—Y12 at Oak Ridge, Sandia, Los Alamos, Lawrence Livermore—participate in a process to determine jointly the priorities among proposed CRADAs for allocation of their CRADA funding.[27] DP CRADAs are required to be "dual use" CRADAs—i.e., demonstrate both a defense-related and a nondefense-related use for the research. ER CRADAs are generally funded on the laboratory side by block funding, where DOE pays the laboratory a block amount for a specified set of deliverables. The laboratory then must find a company that might want a CRADA, referred to as a spinoff CRADA.[28] One benefit of having laboratories seek corporate CRADA partners, rather than the reverse, is that the companies may become involved at an earlier stage of the research.

According to a recent industry survey, most companies are primarily interested in accessing expertise and unique facilities at federal laboratories, as opposed to establishing a collaboration toward direct product development for sale in the marketplace.[29] The survey data implied that the purpose of entering into CRADAs or other collaborative relationships with the laboratories is less to license anything so developed than to undertake research.

Recently, CRADAs have prompted controversy. Some policymakers view CRADAs as mechanisms for unwarranted support of research that should be left to industry. Some see CRADAs as a form of subsidy to industry, at a time of increasing federal budget constraints. Some proposals advocate that DOE CRADAs be terminated and that some National Laboratories be privatized or terminated. Proponents of CRADAs view them as mechanisms for federal laboratories to leverage resources provided by their CRADA partners in areas relevant to DOE missions, and for laboratory personnel to gain knowledge through collaborations.

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[24] D. Blumenthal and N. Causino, "Life Science CRADAs at the National Institutes of Health and Department of Energy Laboratories," contractor document prepared for the Office of Technology Assessment, U.S. Congress, Washington, DC, February 1994.

[25] D. Blumenthal and N. Causino, "DOE and NIH CRADAs," contractor document prepared for the Office of Technology Assessment, U.S. Congress, Washington, DC, April 1993.

[26] M. Chalhoub, "Public-Private Partnerships through Cooperative Research and Development Agreements: Role of the National Labs in Commercializing Environmental Technologies," contract document prepared for the Office of Technology Assessment, U.S. Congress, Washington, DC, April 1995.

[27] D. Blumenthal, and N. Causino, "Life Science CRADAs at the National Institutes of Health and Department of Energy Laboratories," contractor document prepared for the Office of Technology Assessment, U.S. Congress, Washington, DC, February 1994.

[28] Ibid.

[29] J.D. Roessner, "What Companies Want From the Federal Labs," *Issues in Science and Technology* 10:37-42, 1993.

Access to National Laboratory expertise, research tools, and scientific capabilities is by no means limited to CRADAs. According to DOE officials, the National Laboratories generally negotiate thousands of non-CRADA agreements annually. For example, cost-shared contracts and subcontracts with other partners are an important method for joint technology development with DOE.[30] These agreements can be used to leverage federal resources through cost sharing with the private sector and other federal agencies. Some of these R&D partnerships seek to accelerate and facilitate demonstration of promising environmental remediation technologies while reducing costs. Contracts are supported by direct funding from DOE, and subcontracts are awarded to R&D laboratories.[31] In FY 1994, 39 percent of DOE/Environmental Management Technology Development funding was in the form of contracts or subcontracts. These most often involve industry partners, universities, or interagency agreements with other federal agencies. DOE sources claim that this mechanism spreads risk, and stretches federal R&D funding by leveraging the participation of partners.[32]

[30] Information provided by the Office of Environmental Management, Department of Energy, Washington, DC, May 1995.

[31] Ibid.

[32] Ibid.

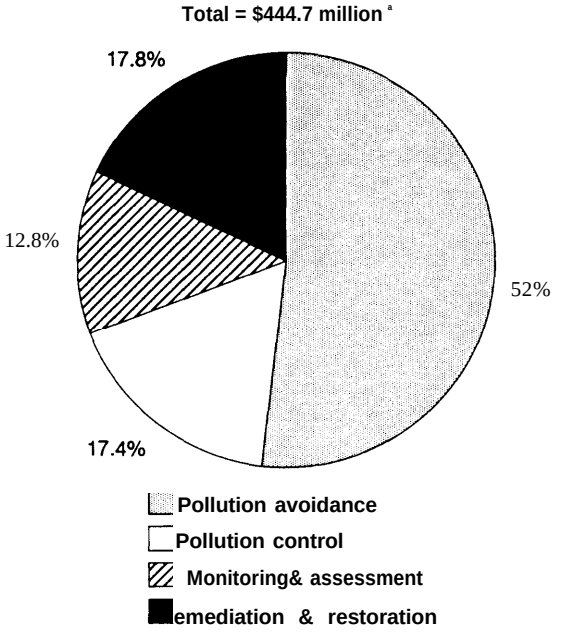
Department of Defense 4

Like the Department of Energy, the Department of Defense (DoD) has major environmental responsibilities, and a multibillion dollar environmental budget. The most publicized DoD environmental chore is to clean up or manage contamination in and around military facilities, here and abroad, arising from military operations.[1] Estimates of the overall bill for cleanup and related activities range into the tens of billions of dollars over the next few decades. About 95 Defense installations are listed as EPA Superfund sites. Cleanup activities are undertaken on 1,700 defense installations around the world, as well as at numerous Defense bases proposed for closure and transfer out of DoD management. Studies are being conducted at many other potentially contaminated sites to determine cleanup needs.

While less publicized, DoD spends as much or more each year to bring its ongoing operations into compliance with U.S. environmental standards as it does on cleanup. For example, it needs to find substitutes for ozone depleting substances currently in use. Finally, DoD is a major land management agency, with approximately 25 million acres under its jurisdiction; management of these lands in an environmentally responsible fashion is a continuing DoD resource management issue: for example, the agency conducts training activities in the field while simultaneously needing to protect threatened and endangered species.

[1] This report does not discuss environmental challenges associated with dismantling nuclear weapons and managing nuclear materials. For discussion of this issue, see Office of Technology Assessment, *Dismantling the Bomb and Managing the Nuclear Materials*, OTA-O-572, (Washington, DC: U.S. Government Printing Office, September 1993).

FIGURE 4-1: Allocation of DoD Environmental Technology R&D and Scaleup by Category, FY 1994 (in percent)



● Total is based on data displayed in table 2-1 in chapter 2.
SOURCE: National Science and Technology Council, unpublished data, Apr. 6, 1994.

Cleanup operations and compliance activities consumed most of the nearly $4.6 billion DoD spent on environmental activities in FY 1994.[2] Environmental costs are mounting. DoD estimates that it could need $25 billion for environmental activities from FY 1995 through FY 1999.[3] The need for more cost effective ways to address environmental issues seems clear.

DoD's environmental technology activities support its environmental program, and include remediation, pollution avoidance, pollution control, and monitoring and assessment (see figure 4-l). As shown in table 4-1, DoD spent about $400 million in FY 1994 on environmental technology development activities. (Not all of DoD's spending for such activities as pollution prevention and energy conservation are encompassed in this figure). These expenditures could produce technologies or approaches that reduce compliance costs or otherwise produce savings compared with conventional approaches. A recent report by a Defense Science Board task force on environmental security identified seven steps that could help DoD achieve environmental goals at a time of significant constraints on environmental budgets, including:

- prioritizing environmental investments through comparative risk reduction,
- implementing pollution prevention actions,
- evaluating and deploying new commercial technology more rapidly for DoD use,
- investing in early development and deployment of emerging technology aimed at unique defense requirements,
- improving environmental management efficiency and effectiveness through use of benchmarking and metrics,
- adjusting environmental legislation consistent with risk reduction priorities, and
- maintaining stable funding for environmental activities over the next five years.[4]

As DoD is one of the largest funders of environmental technology R&D, questions about how to optimize returns from this public investment have arisen. DoD's environmental technology activities cross the spectrum from basic research,

[2] According to the U.S. General Accounting Office, DoD, in FY 1994, spent $1.965 billion for defense environmental restoration account activities; $160 million for base realignment and closure activities; and $2,482 billion for compliance, conservation, protection, and prevention. Testimony of David R. Warren, "Environmental Protection: Challenges in Defense Environmental Program Management," before the Subcommittee on Military Readiness and Military Installations and Facilities, Committee on National Security, House of Representatives, U.S. Congress, Washington, DC, Mar. 24, 1995, p. 4.

[3] As cited in Ibid.

[4] Department of Defense, Office of Under Secretary of Defense, Acquisition and Technology "Report of the Defense Science Board Task Force on Environmental Security," Washington, DC, Apr. 22, 1995, p. ES2.

TABLE 4-1: Department of Defense Environmental Technology RDDT&E Programs ($ millions)

	FY 1994 (actual)	FY 1995[a] (estimate)	FY 1996[a] proposal Clinton Administration
Army	91.3	79.5	32.9
Navy	76.0	60.8	76,8
Air Force	10.5	6.1	11.3
Defense-wide:	68.1[b]	38.5	24.1
Advanced Research Projects Agency	—	43,9	14.9
Environmental Security Technology Certification Program	154.1	55.1	58.4
Strategic Environmental Research & Development Program			
Total	400.0	283.9	218.4

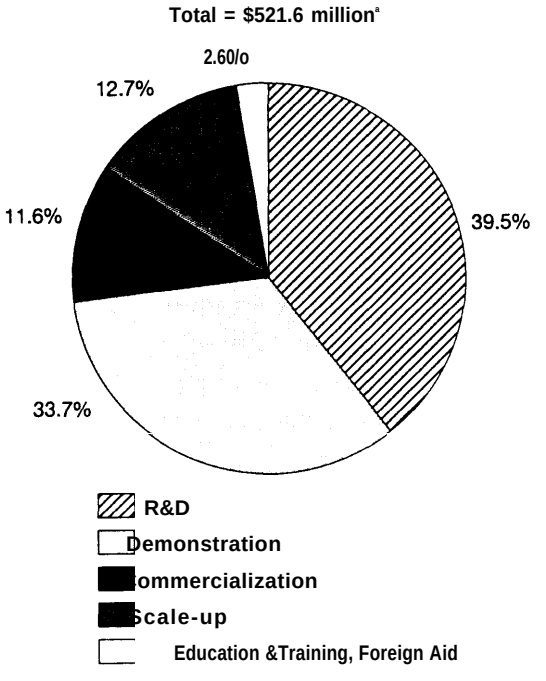
Key: RDDT&E=research, development, demonstration, test, and evaluation.
[a]Figures cited above may differ from other estimates, such as in table 2-1 in chapter 2, due to differences in methodologies, definitions, or programs covered in data collection.
[b]Figure does not include $10 million in unreleased funds.

SOURCE: Department of Defense, 1995.

through development, demonstration, testing, and evaluation, to validation, deployment, and transfer. (See figure 4-2). Some of the technologies it develops could be useful to other federal agencies, state governments. and/or the private sector; while, at the same time, many environmental technologies developed elsewhere could be used effectively by DoD. Establishing effective means for technology cooperation and transfer among different components of DoD itself, between DoD and other federal agencies; and between DoD and nonfederal entities is thus an important need. Several programs and mechanisms, both inside and outside of DoD. have been set up to facilitate cooperation among these parties.

Selected aspects of DoD's environmental technology programs are briefly discussed below. Most of the discussion focuses on priority setting for environmental technology through reorganization and development of an environmental technology strategy. Also discussed are the Environmental Security Technology Certification Program, the Strategic Environmental Research and Development Program (SERDP), and various Advanced Research Projects Agency (ARPA) activities. The focus is on Defense-wide activities; the individual services also have their own activities, but these are not discussed here.

FIGURE 4-2: DoD Environmental Technology Budget by Function, FY 1994[a]



[a]Total is based on data displayed in table 2-1 in chapter 2

SOURCE National Science and Technology Council, unpublished data, Apr. 6, 1994

BOX 4-1: Selected DoD Environmental Security Functions

Assistant Deputy Under Secretary of Defense (Environmental Technology): Identifies requirements, sets priorities, oversees demonstrated and validated technology and technology transfer to DoD users.

Assistant Deputy Under Secretary of Defense (Cleanup): Carries out an environmental restoration program at DoD facilities; guides DoD cleanup efforts, including cleanup and remediation of asbestos, lead-based paint, and radon at DoD installations.

Director (Environmental Quality-Compliance): Works on compliance with statutory and regulatory requirements for all environmental security functions.

Director *(Environmental Quality-Conservation):* Provides planning, management, protection, preservation, conservation (including energy), and impact analysis for air, land, and water resources for which DoD is steward or a user, including DoD construction, installation maintenance and repair, and installations operations and management.

Director (Environmental Quality-Pollution Prevention): Develops pollution prevention policy, establishes requirements, and monitors source reduction and other practices that reduce or eliminate the creation of pollutants.

SOURCE: Office of Technology Assessment, 1995: adapted from Information provided by DoD and information contained in U.S. General Accounting Office, New *Environmental Security Faces Barriers,* GAO/NSlAD-94-142 (Washington, DC: U.S. Government Printing Office, September 1994)

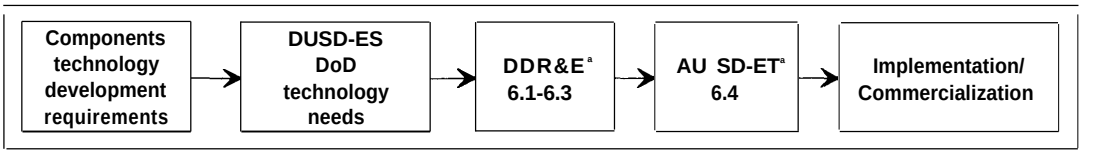
ORGANIZATION FOR ENVIRONMENTAL TECHNOLOGY

At the department level, environmental technology responsibilities are shared by the Deputy Under Secretary for Environmental Security (DUSD-ES) and the Director of Defense Research and Engineering (DDR&E). The DUSD-ES, a new position set up in early 1993, contains offices organized in five mission areas: cleanup, compliance, conservation, pollution prevention, and technology. (See box 4-1). The technology function is considered a crosscutting issue pertinent to the other four missions. A process has been developed to identify and set priorities for environmental technology among Defense users. The process is intended to focus environmental technology research, development, testing and evaluation (RDT&E) on top priority environmental requirements within DoD, and to provide a means to track progress in meeting those requirements.

As shown in figure 4-3, DDR&E oversees basic research, exploratory development, and advanced development (the so called 6.1, 6.2, and 6.3 activities). DUSD-ES is responsible for establishing user-based requirements, oversees demonstration and validation (6.4 activity), and the transfer of environmental technology.

A Defense Environmental Security Council and committee structure has been set up to assist the DUSD-ES. The Council participates in the Defense Performance Review, Secretary of Defense decisions on roles, missions, and functions, and base realignment and closure actions. Environmental matters in the military services are under the Assistant Secretary for Installations, Logistics, and Environment.

FIGURE 4-3: Environmental RDT&E Process Relationships



[a]In DoD budget terms, category 6 I refers to research into basic and applied sciences; 6.2 refers to exploratory development Of practical applications of the research; 6.3A refers to building of prototypes to demonstrate the principal of applications; 6.3B and 6.4 entail development of specific systems linked closely to procurement.

KEY: ADUSD-ET=Assistant Deputy Under Secretary of Defense for Environmental Technology, DDR&E=Director of Defense Research and Engineering; DUSD-ES=Deputy Undersecretary of Defense for Environmental Security.

SOURCE: Office of the Deputy Under Secretary of Defense for Environmental Security, Department of Defense, *DoD Environment/ Technology Requirements Strategy,* Washington, DC, Mar. 15, 1995.

The U.S. General Accounting Office (GAO) recently reviewed DoD's environmental security strategy[5] and its environmental security program. GAO anticipated some difficulties in overcoming several long-standing barriers, including: 1) limited cooperation between DoD and other agencies, 2) constraints in implementing environmental regulations, and 3) inconsistent environmental funding methods.

Priority Setting

DoD has developed a process to identify environmental technology needs to meet its overall goals of cleanup, compliance, conservation, and pollution prevention. A *DoD Environmental Technology Requirements Strategy*[6], issued in May 1995, discusses the process DoD is using to match technology investments with these DoD environmental priorities. The goals for technology research, development, testing and evaluation are identified under four broad environmental quality goals:

Cleanup technology: increase the effectiveness of cleanup efforts while "reducing the time and costs to assess, characterize, and treat DoD contaminants."

Compliance technology: support efforts to ensure that "all applicable environmental laws, rules, and regulations as put forth by appropriate regulatory entities are met." Examples include technologies for environmental monitoring, waste treatment, recycling and disposal, marine risk assessment, and environmental management.

Conservation technology: use new and innovative technology to decrease environmental risk and future environmental costs in use and management of cultural, biological, and natural resources under DoD's jurisdiction.

Pollution prevention technology: seek out cost-effective, in-process methodologies to meet long-term DoD environmental obligations. Examples include design of less polluting manufacturing or maintenance practices, substitutions, and use of life cycle assessments. DoD is placing increased emphasis on source reduction and other pollution prevention approaches, as discussed in box 4-2.

DoD is in the process of aligning environmental technology R&D with standard DoD acquisi-

[5]U.S. General Accounting Office, *New Environmental Security Strategy Faces Barriers.* GAO/NSIAD-94-142 (Washington, DC: U.S. General Accounting Office September 1994).

[6]Office of the Deputy Under Secretary of Defense for Environmental Security, U.S. Department of Defense, *DoD Environmental Technology Requirements Strategy,* Washington, DC, Mar. 15, 1995.

BOX 4-2: DoD Pollution Prevention Policy and Activities

in December 1993, DoD issued a policy statement committing the department to adherence with the 1990 Pollution Prevention Act (Public Law 101-508), as required of all federal agencies by Executive Order 12856. The 1990 Act establishes a preference for preventing or reducing pollution at the source when feasible, and sets up a hierarchy among other options (recycling, treatment and disposal in order of desirability).

DoD policy states that "the solution to long-term cleanup and compliance is the development and acquisition of environmentally sound defense systems. This is based on the belief that pollution prevention will limit the extensive cleanup and compliance costs and reduce risks to military and civilian personnel, the public, and the environment".

Pollution prevention activities are underway in a broad range of DoD areas, including acquisition and procurement practices, development of innovative technology, and through creation of better chemical management and accounting systems.

As mentioned, pollution prevention is one of four goals in DoD's environmental technology strategy. Some of DoD's technology goals for pollution prevention could have applications outside of DoD, including in industry, such as:

- Development of less-polluting and less-toxic methods for surface cleaning and decreasing of weapons systems, ships, aircraft, and components.
- Improving processes and developing new formulations to reduce hazardous materials and volatile organic compounds (VOCs) in painting and coating, stripping, and ordnance manufacturing and *use.*
- Development of safe and affordable alternatives to ozone-depleting substances used in climate control and refrigeration, solvents in manufacturing and maintenance operations, and firefighting agents for facilities, weapons systems, ships and aircraft.
- Reductions in DoD use of 17 **toxic** chemicals through use of alternative substances and processes;
- Development of predictive models to aid in environmental risk and life cycle cost assessments;
- Reduction in DoD's greenhouse gas emissions, and expansion of DoD's use of renewable energy sources and substitutes.

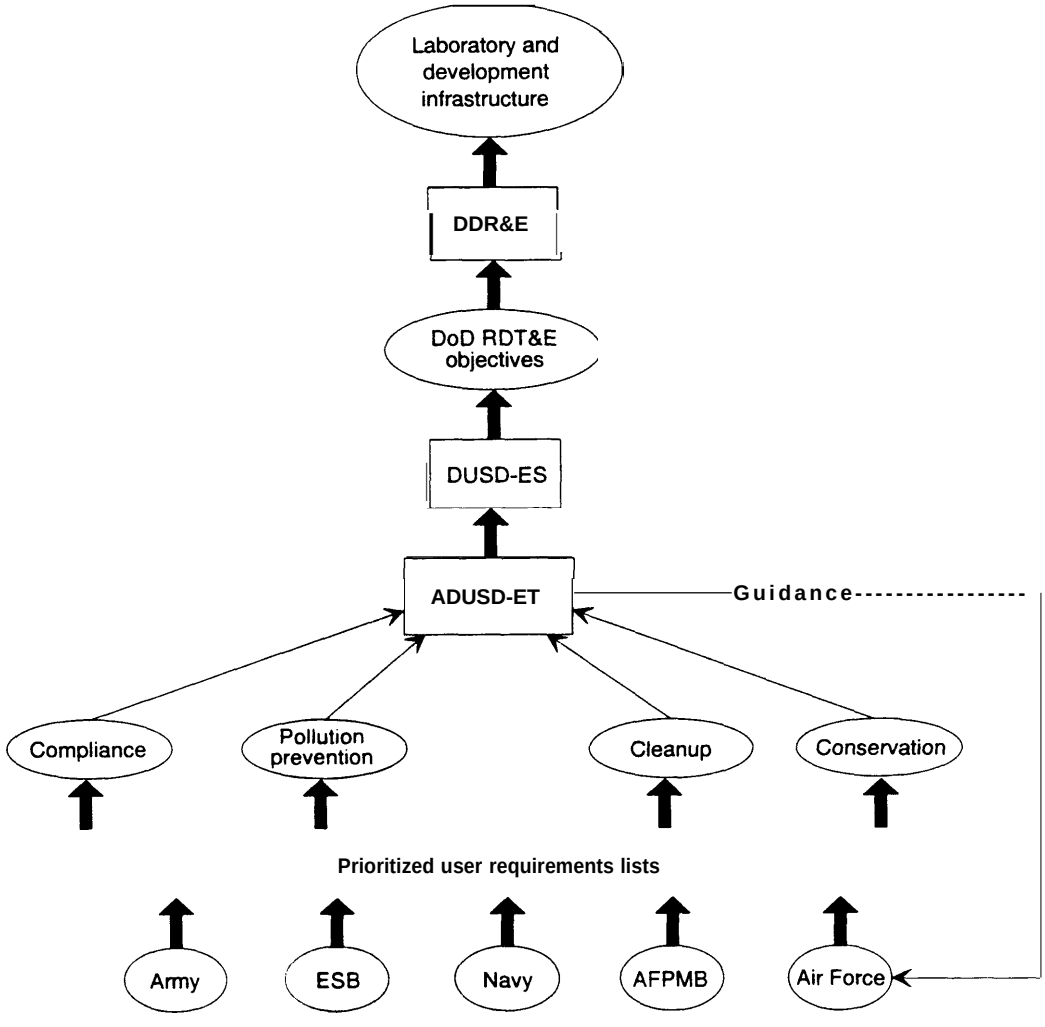
The status of DoD's pollution prevention efforts were recently reviewed by the U.S. General Accounting Office.[1] GAO **noted that** DoD has set up a DoD-wide system to obtain information on toxic chemicals; but the agency expressed uncertainty about whether DoD would meet the July 1995 deadline for this effort. It concluded that current information was inadequate to determine the extent to which toxic chemical use had been reduced. GAO noted that more research, development, testing, and evaluation would be needed to "identify potential substitute processes and materials. "It also noted that the military services believe that the estimate of $2 billion needed to meet pollution prevention needs from FY 1994 through FY 1999 could be underestimated.

SOURCE: Office of Technology Assessment, 1995.

[1]U.S. General Accounting Office, *Pollution Prevention: Status of DoD's Efforts,* GAO/NSIAD-95-13 (Washington, DC U.S. Government Printing Office, November 1994).

tion policy. In the past, unless installation commanders applied operation and maintenance funds for demonstration, testing, and evaluation, environmental technology developed in the laboratory often remained in the laboratory. This may change, in part because the DUSD-ES can support testing and evaluation of environmental technologies through the new Environmental Security Technology Certification Program (ESTCP), discussed below.

FIGURE 4-4: DoD Environmental Technology Planning Process Overview



KEY: ADUSD-ET=Assistant Deputy Under Secretary of Defense for Environmental Technology; AFPMB=Armed Forces Pest Management Board; DDR&E=Director of Defense Research and Engineering; DUSD-ES=Deputy Undersecretary of Defense for Environmental Technology; ESB= Explosives Safety Board.

SOURCE: Office of the Deputy Under Secretary of Defense for Environmental Security, Department of Defense, *DoD Environmental Technology Requirements Strategy,* Washington, DC, Mar 15 1995

Environmental problems of one sort or another occur at most Defense installations. Hence, effective dissemination of information about how to address these problems is critical. In many cases, effective techniques or technologies to address a problem may be available but not known by base commanders. In such cases, a potential exists for duplication of efforts or reliance on more expensive alternatives.

Figure 4-4 shows a simplified schematic of DoD's environmental technology planning process. Each of the services has its own process for identifying a user list of priorities for environmental technology R&D. The lists are analyzed and

prioritized by the office of the Assistant Deputy Under Secretary of Defense for Environmental Technology. The priority list then is used DUSD-ES and the Director of Defense Research and Engineering to match program funding with priority projects, as requested by users.

ENVIRONMENTAL SECURITY TECHNOLOGY CERTIFICATION PROGRAM

It is often difficult for innovative environmental technologies to gain acceptance. Reasons for this include uncertainty about the performance of the new technologies and reluctance of users to invest in approaches that may not pass muster with regulations. This new technology certification program is used to demonstrate and validate the performance of technologies that meet DoD priority needs for cleanup, compliance, and pollution prevention. The objective is to reduce the cost and risk to DoD of meeting its environmental obligations.

Candidate technologies can be federally developed or developed by the private sector. The demonstrations are conducted at DoD sites. The technologies are tested in operational settings to determine their suitability for DoD use in terms of regulatory requirements, end-user needs, and cost effectiveness. Twenty-four demonstrations were initiated in FY 1995. These technologies are expected to yield cost (and/or time) savings for DoD compared to current practice or conventional technology.

Information about ESTCP demonstrations will be publicly available. As a result, technologies that fare well in the certification program may gain broader acceptance elsewhere.

STRATEGIC ENVIRONMENTAL RESEARCH AND DEVELOPMENT PROGRAM

SERDP, set up by Congress in 1990 through Public Law 101-510, supports basic and applied research and development of technology to enhance DoD and Department of Energy (DOE) capabilities to meet their environmental obligations. The program also seeks to foster information and technology exchange among government agencies and the private sector, and to find more cost-effective ways to lower environmental risks through use of existing science and technology. About $154 million was spent on SERDP during FY 1994; the estimate for FY 1995 is $55 million.

The program is conducted by DoD, DOE, and Environmental Protection Agency, with participation by the National Ooceanic and Atmospheric Administration, the National Aeronautics and Space Administration, and some other agencies. Among other things, SERDP can be used to:

- Identify research, technologies, and other information developed by DoD and DOE for national defense purposes that would help government and private sectors in developing technologies for addressing environmental concerns.
- Share DoD and DOE research, technologies, and other information with government and private organizations.
- Furnish government and private organizations with data and enhance data collection and analytical capabilities for conducting environmental research, including global environmental change research.
- wdentify private sector technologies that are useful for DoD and DOE defense activities in addressing environmental requirements.

SERDP activities include global environmental change and energy conservation and renewable resources, as well as cleanup, compliance, conservation, and pollution prevention. Table 4-2 shows FY 1993 spending in each of these areas. Most of the SERDP funds are distributed to laboratories at DoD, EPA, and DOE, or other federal laboratories; over half of the funds are eventually expended by private industry or universities. Table 4-3 shows the distribution of these funds by agency.

TABLE 4-2: SERDP FY 1993 Funding Summary ($ millions)

	Congressional Interest	Project	FY 1993 Total
Installation restoration	3.5	32.0	35.5
Compliance	2.3	12.6	15.0
Conservation	0.8	8.1	8.9
Alternate/Clean Energy	0.0	8.1	8.1
Global environmental change	5.0	65.2	70.2
Pollution prevention	0.0	31.6	31.6
Undistributed reductions			10.2
FY 1993 Scientific Advisory Board and Council support			0.5
FY 1993 appropriation total			**180.0**

SOURCE: Strategic Environmental Research Development Program (SERDP), 1994 *Annual Report and five-Year (7994-7998) Strategic Investment Plan,* Arlington, VA, September 1994.

The DoD (Army, Navy, and Air Force) and EPA are cooperating (under SERDP sponsorship and funding) in the National Environmental Technology Demonstration Sites program to develop facilities for testing the performance of environmental technologies. About $19 million in SERDP funds have been committed since FY 1993 for the preparation of five demonstration sites at military installations. The objective of this effort is to permit side-by-side demonstrations and evaluations of innovative technologies under controlled conditions. Priority will be given to technologies developed through SERDP; but some of these sites may be used by ESTCP (described earlier) as well as other government and private sector technology developers.

TABLE 4-3: Distribution of SERDP Funds to Laboratories, FY 1993 ($ millions)

Department of Defense laboratories	
Army	29.7
Air Force	11.3
Navy	45.8
Department of Energy laboratories	17,4
Environmental Protection Agency laboratories	17.1
Other federal recipients	47.9

SOURCE. Strategic Environmental Research Development Program (SERDP), 1994 *Annual Report and Five-Year (1994-1998) Strategic Investment Plan,* Arlington, VA, September 1994

ARPA SUPPORT FOR ENVIRONMENTAL TECHNOLOGY AND ACTIVITIES

The DoD Advanced Research Projects Agency supports advanced basic and applied research and development projects, including prototype projects, pertinent to DoD missions. ARPA does not conduct this R&D itself, but arranges for the work to be performed at military or other government laboratories, by defense industry contractors, or at universities.

ARPA supported about $68 million in environmental technology research and development in FY 1994. This does not include sizable ARPA spending on fuel cell, battery, photovoltaics technologies, and some advanced manufacturing technologies that could have environmental quality benefits. Much of ARPA's environmental work is conducted in partnership with defense industry firms.

ARPA R&D in the pollution prevention area includes ongoing work to reduce the environmental impact of electronics manufacturing. Some of this is carried out through SEMATECH, an R&D consortium with the semiconductor industry, with the aim of reducing reliance on ozone depleting substances in the manufacture of semiconductor chips. ARPA also supports several R&D projects to develop environmentally preferable technolo-

gies for use in the printed wiring board industry, including both drop-in technologies, and breakthrough technologies.

Another pollution prevention thrust at ARPA involves development of environmentally preferable coating or curing technologies that would reduce the environmental impact of metal plating, finishing, and painting.

ARPA support for cleanup or compliance-related R&D includes work on plastics recycling and also hydrothermal oxidation processes as an alternative to incineration. ARPA plans to support in situ bioremediation R&D in FY 1996.

Some ARPA environmental technology activities are carried out through the Technology Reinvestment Program (TRP). TRP is a dual-use technology project managed by ARPA with the participation of several other agencies, including, DOE, NSF, NASA, the Department of Commerce and Department of Transportation. The program emphasizes defense relevant partnerships that involve cost-sharing between participants and the federal government. A major ARPA effort undertaken through TRP involves development of advanced environmental sensors that would permit on-site characterization of contaminants for cleanup and/or process monitoring. Such technologies could appreciably reduce cleanup costs. Several advanced manufacturing projects funded under TRP also could result in cleaner, more energy efficient manufacturing processes.

Environmental Protection Agency 5

As the major federal environmental regulatory agency,[1] the Environmental Protection Agency's (EPA) greatest influence on environmental technology is through regulation and enforcement, not direct support for R&D. Environmental technology demand is largely driven by regulatory requirements, although some pollution prevention and energy efficiency technologies can be cost-effective even in the absence of strict standards. Environmental laws, regulations, administration of permits, and other policies and procedures sometimes propel and at other times impede environmental technology innovation.

Recognition of the need for EPA to address regulatory or other barriers to technological innovation appears to have grown in recent years. A number of studies, including several by advisory bodies to EPA, have urged the agency to place more emphasis on the potential for innovative technologies to help achieve environmental goals more cost effectively.[2]

The agency has taken some steps to remove impediments and add incentives for technological innovation. A major objective of the agency's recently promulgated Environmental Technology Strategy is to promote innovation (see box 5-1). Another recent

[1] Several other agencies have some environmental regulatory jurisdiction including the U.S. Army Corps of Engineers, Coast Guard, Fish and Wildlife Service, and National Marine Fisheries Service of the National Oceanographic and Atmospheric Administration, among others.

[2] See, for example, U.S. Environmental Protection Agency, National Advisory Council for Environmental Policy and Technology, *Report and Recommendations of the Technology Innovation and Economics Committee: Permitting and Compliance Policy: Barriers to U.S. Environmental Technology Innovation*, EPA 101/N-91/001 (Washington, DC: U.S. Government Printing Office, January 1991).

BOX 5-1: EPA's Technology Innovation Strategy

EPA's Technology Innovation Strategy applies to EPA's own activities and guides priorities for the EPA-led Environmental Technology Initiative. The strategy has four objectives:[1]

- "Objective #l: Adapt EPA's policy, regulatory and compliance framework to promote innovation."
  Strengthen incentives for and remove barriers to innovation in regulatory, permitting, compliance, and enforcement programs at federal, state, and local levels without compromising environmental protection.
- "Objective #2: Strengthen the capacity of technology developers and users to succeed in environmental technology innovation. "
  Work with public and private sector partners to identify and address market inefficiencies and failures affecting environmental technology. Highlight high priority technology gaps. Catalyze innovation and commercialization through "partnerships; providing testbeds, analytical tools, and technical support; and standardizing test protocols to enhance credibility of performance data on innovative technologies. "
- "Objective #3: Strategically invest EPA funds in the development and commercialization of promising new technologies. "
  Directly fund selected technologies that can meet critical needs, offer good breakthrough possibilities, and require timely public financing (and do not supplant private funding).
- "Objective #4: Accelerate the diffusion of innovative technologies at home and abroad."
  Enhance public and private information networks on environmental market needs and technology performance and availability. "Provide technical assistance, training, education, and information management . . . and [strengthen] environmental policy and regulatory framework abroad. " Promote federal procurement of innovative technologies.

As noted, EPA's regulatory and compliance activities have a greater impact on technological change than its direct support of RD&D. Therefore, an objective of the technology strategy is to make the regulatory process more innovation friendly.[2,3] It also suggests greater support for technology performance verifications, test beds, and demonstrations that may help open markets for innovative technology in cases where technology users and permit writers favor old technologies because of perceived regulatory, technical, and economic risks associated with new technology. EPA's strategy also emphasizes partnerships with the private sector as well as with universities, sister federal agencies, state and tribal governments, and localities.

Finally, the strategy recognizes the importance of pollution prevention or cleaner technologies that avoid generation of pollution and waste in the first place. The agency's traditional expertise and regulatory heritage, however, has been in the realm of end-of-pipe control, disposal, and remedial technologies, Indeed, despite EPA's professed emphasis on pollution prevention and its development of several prevention oriented programs, the agency's RD&D resources are still greatest for remediation and restoration. (See table 5-1.)

SOURCE: Office of Technology Assessment, 1995

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[1]This discussion is drawn from Environmental Protection Agency, "Technology Innovation Strategy of the U.S. Environmental Protection Agency," (Washington, DC, external discussion draft, January 1994)

[2]A number of EPA documents discuss this issue including Environmental Protection Agency, National Advisory Council for Environmental Policy and Technology, *Report and Recommendations of the Technology Innovation and Economics Committee: Permitting and Compliance Policy: Barriers to U.S. Environmental Technology Innovation,* EPA 101/N-91/001 (Washington, DC: U.S. Government Printing Office, January 1991)

[3]Also, see discussion in U.S. Congress, Office of Technology Assessment, *Industry Technology and the Environment, Competitive Challenges and Business Opportunities,* OTA-ISC-586 (Washington, DC: U.S. Government Printing Office, January 1994) Another OTA report, forthcoming in the summer of 1995, discusses environmental policy tools from the context of renovation and other factors

activity, called the Common Sense Initiative, seeks consensus among stakeholders in several industrial sectors about ways to accomplish environmental goals more cost effectively, including removal of barriers to technological innovation. Encouraging innovation is also an objective of Clinton Administration's Environmental Technology Initiative (ETI), discussed below, for which EPA has lead-agency responsibilities.

Many of these efforts focus as much or more on removing regulatory impediments to new environmental technology commercialization as they do on providing direct R&D support. The complex relationships, both positive and negative, between environmental regulations and environmental technology innovation, are addressed in other OTA work, to which the reader is referred;[3] this paper focuses primarily on EPA's direct support for environmental technology R&D.

ENVIRONMENTAL TECHNOLOGY R&D SPENDING

EPA's interest in technology development is at least threefold. The agency relies on some kinds of technologies in performing its regulatory mission. Examples include technologies for measuring, monitoring, and modeling transport and fate of pollutants; for determining health and ecological impacts of chemicals, pollutants, and environmental degradation; and for monitoring compliance by regulated entities.

It also makes use of technologies in carrying out environmental compliance activities for which it has direct responsibility. The agency has responsibility under Superfund[4] for cleaning up abandoned hazardous waste sites for which responsible parties cannot be found or are unable to pay for remediation. EPA is also obliged to see that its own laboratories and other facilities meet environmental requirements.

More broadly, the agency is interested in technologies that can help companies, municipalities and other government entities, households, and others meet standards and improve environmental performance. This third interest derives from EPA's need to determine technological and economic feasibility of compliance options as well as the agency's broader mission to promote environmental quality.

As is discussed in chapter 2, estimates of environmental technology research, development, and demonstration (RD&D) spending by EPA and other agencies should be viewed with caution. The line separating environmental technology RD&D from other activities that may have a technological component (e.g., scientific research; technical assistance; risk, health, and ecological assessment; and regulatory support) is often arbitrary. Moreover, a single program may include several of these activities, so that the technological component may be difficult to separate out in a consistent fashion. Also, there can be instances of double counting where resources are shared or transferred among different programs, offices, and agencies.

According to National Science and Technology Council (NSTC) data, EPA spent about $94.2 million on environmental technology RD&D, and an additional $18.6 million on technology scaleup and commercialization activities in FY 1994.[5] For FY 1995, EPA estimates that it will spend $100.8 million for RD&D and $45.9 million for scaleup and commercialization. (See table 5-1.) It should be noted that technology R&D is only a portion of EPA's total R&D; most of EPA's research budget is for environmental and related health sciences,

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[3] See, especially, U.S. Congress Office of Technology Assessment, *Industry, Technology, and Environment: Competitive Challenges and Business Opportunities*, OTA-ISC-586 (Washington, DC: U.S. Government Printing Office, Jan. 1994), pp. 54-59, 81-87, 122-124, 210-220, and 263-289. Another OTA study on environmental policy tools, is forthcoming in the summer of 1995.

[4] Formally, the Comprehensive Emergency Response, Compensation, and Liability Act of 1980 (Public Law 96-510).

[5] National Science and Technology Council, Committee on Environment and Natural Resources and Committee on Civilian Industrial Technology, Joint Subcommittee on Environmental Technology, unpublished data, Apr. 6, 1994.

TABLE 5-1: Estimated EPA Support for Environmental Technology RD&D ($ millions)

Category	FY 1993	FY 1994	FY 1995
Pollution avoidance	17.3	25.8	30.4
Pollution control	12.6	17.9	16.9
Monitoring and assessment	14.3	15.1	16.5
Remediation and restoration	34.3	36.4	37.0
Subtotal	**78.5**	**95.1**	**100.8**
Scaleup and commercialization, all categories	8.3	18.6	45.9
Total *	**86.8**	**113.8**	**146.7**

SOURCES. National Science and Technology Council, Committee on Environment and Natural Resources and Committee on Civilian Industrial Technology, Joint Subcommittee on Environmental Technology, unpublished data, Apr. 6, 1994.

including such activities as toxicological studies, risk assessments, ecological studies, and basic science research. Total EPA R&D spending is estimated to be $535 million for FY 1994 and $589 million for FY 1995.[6,7]

Relative to several other federal departments and agencies, EPA's funding for environmental technology RD&D is modest. It accounted for only about 5 percent of the total spending by federal agencies on environmental technology RD&D in FY 1994 (using OTA's estimate of the total). The Departments of Energy (DOE), Defense (DoD), Agriculture (USDA), and the National Aeronautics and Space Administration (NASA) fund more environmental technology RD&D than EPA.

ENVIRONMENTAL TECHNOLOGY INITIATIVE

EPA is the lead agency for the Environmental Technology Initiative (ETI), which includes participation from DOE, DoD, USDA, the Department of Commerce (DOC), NASA, National Science Foundation (NSF), and other agencies. ETI received $36 million in FY 1994 and $68 million in FY 1995. About $15 million of ETI's FY 1994 spending was passed through EPA to other federal agencies. (See table 5-2.) The Clinton Administration requested $120 million for FY 1996; Bills reported by the House Committee on Science and the House Committee on Appropriations have proposed zeroing out or greatly reducing the ETI budget.

ETI's main FY 1995 solicitation is directed to federal, state, and tribal agencies. Private entities and local governments are able to participate indirectly as partners, grantees, or contractors. Two other solicitations set aside about 6 percent each of FY 1995 ETI funding for advanced stage Small Business Innovation Research (SBIR) projects, and for projects from universities and other nonprofit organizations. About 25 percent of FY 1995

[6] National Science and Technology Council, Committee on Environment and Natural Resources, unpublished data; and Office of Management and Budget, *Budget of the United States Government: Fiscal Year* 1996 (Washington, DC: U.S. Government Printing Office, 1995), pp. 94, T. 7-1.

[7] Congress was still considering FY 1996 authorizations and appropriations for EPA as this report went to press. The House Committee on Science had just reported H.R. 1814, which would authorize $490 mi11ion for EPA's Office of Research and Development (ORD) for FY 1996. The amount includes RD&D and related program management and support by ORD; some R&D by EPA is not conducted by ORD. Funds for technology development activities are not specified. The bill would not authorize funds for the Environmental Technology Initiative, the Climate Change Action Plan, or indoor air pollution research.

The House Committee on Appropriations had reported out a measure to the full House of Representatives, which recommended a one-third reduction in overall EPA funding for FY 1996. Within this total it recommended that $384 million be appropriated for ORD activities—an increase over ORD's FY 1995 appropriation-but proposed no funds for the Environmental Technology Initiative.

TABLE 5-2: Federal Agency Recipients of FY 1994 Environmental Technology Initiative Funding Other Than EPA ($ thousands)

Agency	Funding
Department of Energy	$3,350.2
National Institute of Standards and Technology	2,903.6
Department of Defense[a]	2,731.3
Department of Commerce[b]	1,536.9
Bureau of Mines	1,154.3
Tennessee Valley Authority	1,001.7
Department of Agriculture	900.0
Small Business Administration	703.9
Agency for International Development	309.4
National Science Foundation	180.0
U.S. Coast Guard	120.0
National Aeronautics and Space Administration	30.0
Bureau of Prisons	50.0
Other	75.0
Total	15,046.3

[a] Includes individual services and U.S. Army Corps of Engineers
[b] Other than National Institute of Standards and Technology.
SOURCE: Environmental Protection Agency

ETI funding is designated to support projects under the National Action Plan for Global Climate Change and is not part of the other ETI solicitations.[8]

ETI's FY 1994 program plan enumerates 73 activities falling in four major categories:[9,10]

1) Environmental and Restoration Technologies (24 projects/activities; $11.5 million)
   Research, development, demonstration, testing, and evaluation of monitoring, pollution prevention, control, and remediation technologies. Criteria for selection include meeting critical environmental needs and prospects for technological breakthrough in reasonable time.
2) Clean Technology Use by Small Business (24 projects/activities: $11.3 million)
   Technical assistance for pollution prevention, joint RD&D with industry, and catalyzing design of safer chemicals, products, and processes. Several Design for the Environment projects are included.
3) U.S. Technology For International Solutions (US TIES)
   (11 projects/activities; $10.8 million)
   Promotes use of U.S. technologies and expertise abroad through technical assistance, training, demonstrations, market and needs assessment, and participation with industry in international standards development.
4) Gaps, Barriers, and Incentives
   (13 projects/activities; $1.7 million)
   Identifies environmental technology gaps and needs; identify and remedy regulatory barri-

[8] Environmental Protection Agency, "Environmental Technology Initiative: Program Solicitation Package FY 1995," EPA 542-B-94-010 (Washington, DC: July 1994).

[9] Environmental Protection Agency, *U.S. EPA Environmental Technology Initiative: FY 1994 Program Plan* (Washington, DC: U.S. Government Printing Office January 1994).

[10] Environmental Protection Agency, untitled mimeo listing FY 1994 Environmental Technology Initiative projects, May 1, 1995.

ers; and test and evaluate innovation friendlier permitting, inspection, and enforcement approaches.

In addition, five SBIR projects garnered $771,000 in FY 1994 ETI funding.

ETI's FY 1995 solicitation is divided into six topic areas:

1) policy framework,
2) innovation capacity,
3) environmental technologies,
4) pollution prevention technologies,
5) domestic diffusion, and
6) international diffusion.

These areas are arrayed across the four objectives of EPA's Technology Innovation Strategy. (See box 5-A.)

As with the Technology Innovation Strategy, ETI's activities run the gamut from "hard" technology RD&D to "softer" activities on regulatory and compliance approaches, management and accounting tool development, technical assistance and information dissemination, and other efforts that do not fall strictly under the RD&D category but may be quite important to shaping the climate for technological innovation.

ORGANIZATION FOR ENVIRONMENTAL TECHNOLOGY

EPA's environmental technology responsibilities are shared among several offices. The Office of Policy, Planning, and Evaluation helps develop the agency's technology policies and has lead responsibilities for management of the Administration's Environmental Technology Initiative. R&D is carried out through the Office of Research and Development (ORD) and the agency's media offices: Office of Air and Radiation (OAR), Office of Pesticides and Toxic Substances (OPTS), Office of Water (OW), and Office of Solid Waste and Emergency Response (OSWER) The internal Innovative Technology Council works on crossoffice priorities. EPA's regional offices and offices responsible for enforcement and education may also have some relevance to technology development and dissemination. The Office of International Activities supports international technology diffusion and technical assistance.

ORD, which conducts intramural R&D and supports extramural research, has been reorganized; its laboratories and centers are now grouped under four units:[11]

- National Center for Environmental Assessment;
- National Risk Management Research Laboratory;
- National Health and Environmental Effects Laboratory; and
- National Exposure Research Laboratory.

A National Center for Extramural Research and Quality Assessment is also being established. Of these new units, the National Risk Management Research Laboratory is germane to development and diffusion of pollution prevention, control, and remediation technologies while the National Exposure Research Laboratory is relevant to development of monitoring technologies.[12] The reorganization is designed to consolidate and streamline

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[11] "EPA Begins Reorganizing Labs; Research Panel Endorses Change," *McGraw-Hill's Federal Technology Report*, Mar. 30, 1995, pp. 11-12.

[12] The National Risk Management Research Laboratory oversees EPA's Risk Reduction Engineering Laboratory (Cincinnati, OH), Air and Energy Engineering Research Laboratory (Research Triangle Park, NC), Robert S. Kerr Environmental Laboratory (Ada, OK), and the Center for Environmental Research Information (Cincinnati, OH). The National Exposure Research Laboratory supervises the Environmental Monitoring Systems Laboratories (Las Vegas, NV and Cincinnati, OH), Atmospheric Research and Exposure Assessment Laboratory (Research Triangle Park, NC), and the Environmental Research Laboratory (Athens, GA). National Research Council, Board on Environmental Studies and Toxicology, *Interim Report of the Committee on Research and Peer Review in EPA* (Washington, DC: National Academy Press, March 1995), Figure 3, p. 21.

ORD's operations although at this time EPA claims to have no plans to shut down any of its laboratories or centers.[13]

EPA supports extramural research through individual grants, grants to such organizations as the American Water Works Association Research Foundation and Water Environment Research Foundation, and support for various university-based centers, including six Hazardous Waste Research Centers and several Exploratory Research Centers.[14] Many of the university-based centers focus on treatment and remediation of hazardous wastes. The Center for Clean Industrial and Treatment Technologies at Michigan Technological University is an example of a center emphasizing pollution prevention. In FY 1994, EPA spent $45.5 million on exploratory grants and centers, of which about $14.5 million was estimated to be for environmental technology R&D.[15]

One extramural grant program—and part of ETI—is the NSF-EPA Partnership for Environmental Research, which includes a Technology For a Sustainable Environment component. This component will award up to $6.5 million in FY 1995 for pollution prevention technology research concentrating on 1) industries dominated by small business, 2) manufacturing operations that occur in various industries (e.g., cleaning and degreasing, coatings, and refrigerants), and 3) environmentally preferable process chemistry and materials manufacturing, including process control technology.[16]

ORD's technology R&D effort addresses all environmental media—air, water, and land—from prevention to remediation and disposal, as well as monitoring.

A major technology evaluation component of EPA is the Superfund Innovative Technology Evaluation (SITE) program. SITE was established in 1986 jointly by ORD and OSWER to support demonstration and testing of innovative remediation technologies.[17] In SITE's demonstration program vendors pay to demonstrate their technologies while EPA pays for planning, sampling, and analysis. The reports generated through SITE provide independent information that potential customers—including federal agencies—may use to consider innovative technology purchases. SITE's budget was $17 million in FY 1993. FY 1994's SITE program was between $10 million and $11 million.[18] A Municipal Innovative Technology Evaluation Program (MITE) for municipal solid waste technologies received $1 million in FY 1993 but was zeroed out for FY 1995. Some pollution prevention demonstration and evaluation projects exist within ETI or are supported through other programs such as the Pollution Prevention Incentives to States program.

EPA's media offices also undertake technology development and diffusion activities. Many of these are directly pertinent to supporting regulatory and compliance functions. However, some, such as the Technology Innovation Office (TIO) in OSWER, are focused on facilitating develop-

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[13] "EPA Begins Reorganizing Labs; Research Panel Endorses Change," *McGraw-Hill's Federal Technology Report*, Mar. 30, 1995, pp. 11-12.

[14] A number of university centers are also part of the National Science Foundation's Engineering Research Centers and Industry-University Cooperative Research Centers system.

[15] Environmental Protection Agency, "Environmental Protection Agency Wide Response to FY96 OMB-NSTC/CENR Data Call," attachment 2 (Washington, DC, Aug. 9, 1994, mimeo).

[16] National Science Foundation and U.S. Environmental Protection Agency, *Interagency Announcement of Opportunity: NSF-EPA Partnership for Environmental Research*, (Washington, DC, Feb. 24, 1995, mimeo).

[17] Environmental Protection Agency, "Innovative Hazardous Waste Treatment Technologies: A Developer's Guide To Support Services" (third ed.), EPA/542-B-94-012, September 1994.

[18] S. James, National Risk Management Research Laboratory, U.S. Environmental Protection Agency, Cincinnati, OH, personal communication, May 3, 1995.

ment and use of innovative environmental technologies relevant to Superfund, Resource Conservation and Recovery Act corrective actions, and leaking underground storage tank remediation.[19] EPA's Innovative Technology Council, which includes representatives from headquarters offices and regional units, provides cross-office review and project recommendations to carry out the agency's Technology Innovation Strategy. Also, Technology Advocates have been designated from each major agency office to facilitate introduction and acceptance of new technologies.

Like other federal research agencies, EPA sponsors a Small Business Innovation Research program. The agency also cooperates with the Small Business Administration and Small Business Development Centers across the country although some of this work is technical and compliance assistance rather than RD&D.

In accordance with the Federal Technology Transfer Act (Public Law 99-502) and subsequent laws to encourage transfer of federally supported technologies to the private sector for commercialization, EPA laboratories have actively engaged in cooperative research and development agreements (CRADAs) as well as patent licensing agreements with corporations. As of July 1994, EPA had 57 CRADAs and 12 patent licensing agreements.[20]

Although not a part of EPA, the National Environmental Technology Applications Corporation (NETAC) was created by EPA in 1988 through a cooperative agreement as a nonprofit subsidiary of the University of Pittsburgh Trust to provide intermediary services to facilitate environmental technology commercialization. Starting with $9 million of seed funds from EPA, NETAC is now financed through contracts with private, state, and federal clients. NETAC provides independent technology evaluation services, and offers technical, marketing, and regulatory assistance to environmental technology innovators.[21]

INTERAGENCY ACTIVITIES

National Science and Technology Council related efforts

EPA participates on the National Science and Technology Council (NSTC), its Committees on Environment and Natural Resources (CENR) and on Civilian Industrial Technology, and the Joint Subcommittee on Environmental Technology (JSET).

Under the aegis of CENR, the Private Enterprise-Government Interaction (PEGI) Task Force, which includes EPA and eight other federal agencies, acts to identify private sector environmental technology R&D and opportunities for federal-private collaboration and data sharing.

EPA and other agencies involved with environmental RD&D are part of the Interagency Environmental Technologies Office (IETO), established under JSET. IETO aims to promote cooperative approaches to development of environmental technologies. Initial activities included consolidation of information on environmental technology needs, research, and expertise across the agencies. IETO is also trying to facilitate public-private collaborations for environmental technology commercialization.

Other Interagency Participation

EPA participates in numerous environmental technology projects and programs in partnership with other federal agencies, states, and other enti-

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[19] Environmental Protection Agency, *Innovative Hazardous Waste Treatment Technologies: A Developer's Guide To Support Services* (3rd ed.), EPA/542-B-94-012, September 1994.

[20] Ball & Associates, "Programs That Support Development and Diffusion of Innovative Environmental Technologies," contractor report prepared for the Office of Technology Assessment, U.S. Congress, Washington, DC, December 1994, p. I-94.

[21] U.S. Congress, Office of Technology Assessment, *Industry, Technology, and the Environment: Competitive Challenges and Business Opportunities*, OTA-ISC-586 (Washington, DC: U.S. Government Printing Office, January 1994), p. 307.

ties. Major federal partners include DoD, DOE, DOC, the Department of Interior (DOI), USDA, and NSF. As is discussed in chapter 3, EPA and DOE jointly manage the National Industrial Competitiveness through Energy, Environment, and Economics Program. It also participates with DOE and DoD in the Strategic Environmental Research and Development Program and the Committee to Develop On Site Innovative Technologies.

Other Federal Programs 6

Several other federal agencies and departments conduct or support R&D pertinent to environmental technology. Some of the more significant programs are briefly highlighted below.

DEPARTMENT OF COMMERCE

Two Department of Commerce (DOC) agencies conduct and support R&D pertinent to environmental technology: the National Oceanic and Atmospheric Administration (NOAA) and the National Institute of Standards and Technology (NIST). In addition, DOC is involved in several interagency activities related to environmental technologies. It plays a major role in promoting environmental technology exports under the Environmental Technologies Exports Strategic Framework[1], an interagency document developed by the Department of Commerce, the Department of Energy (DOE), and Environmental Protection Agency (EPA). The export strategy calls for streamlining U.S. environmental technologies export promotion efforts, and improving export financing mechanisms. The Office of Environmental Technology Exports has been set up in the DOC's International Trade Administration.

DOC's role in the Rapid Commercialization Initiative is discussed in chapter 2. In addition, Department of Commerce officials chair or play prominent roles in the two NSTC Committees with environmental technology responsibilities, the Committee

[1] Department of Commerce, *Environmental Technologies Exports: Strategic Framework for U.S. Leadership* (Washington, DC: Interagency Environmental Technologies Export Working Group, November 1993).

on Environment and Natural Resources (CENR) and the Committee on Civilian Industrial Technologies. The activities of these civilian committees are also discussed in chapter 1.

As this report went to press, Congress was still considering FY 1996 appropriations for DOC. The House Committee on Appropriations had just reported a measure, H.R. 2076, proposing significant reductions in the department's FY 1996 funding compared to FY 1995. The bill would reduce funding for many, but not all, of DOC's science and technology activities, including some related to environmental technology.

DOC Sustainable Development Policy

DOC released a draft policy document, entitled *To Ensure the Nation's Future,*[2] for public comment in December 1994. The document discusses current actions and future opportunities for DOC to contribute to environmentally sustainable development, such as:

- creating opportunities and incentives for businesses, communities and individuals to prosper economically through environmentally sound growth;
- improving environmental monitoring, prediction, and assessment;
- encouraging the development and diffusion of eco-efficient technologies;
- building partnerships between business, government, and communities.

DOC also proposed to promote environmentally sound growth in key industrial and commercial sectors by focusing programs and coordinating policies related to: 1) environmental technologies, 2) marine fisheries management, 3) coastal zone management, and 4) ecotourism.

The policy emphasizes laboratory-based support for the development and testing of environmental technologies. It also seeks to support enabling technologies and industry R&D and diffusion through the Advanced Technology Program (ATP), the Manufacturing Extension Partnership (MEP), the National Information Infrastructure Program, various NOAA programs, and cooperative research and development (CRADAs) with industry. DOC would also seek to support commercialization of what it calls "eco-efficient technologies" by reducing regulatory barriers; developing science-, incentive-, and performance-based regulatory standards; and testing, evaluation, and certification.

The National Oceanic and Atmospheric Administration

NOAA's mission includes environmental components such as promoting global environmental stewardship in order to conserve and wisely manage the Nation's marine and coastal resources, and describing, monitoring, and predicting changes in the Earth's environment in order to ensure and enhance sustainable economic opportunities.

Estimates of NOAA's environmental technology RD&D expenditures vary. According to estimates provided by NOAA to the interagency Committee on Environment and Natural Resources (CENR), NOAA spent a total of about $34 million in FY 1994, and about $35 million in FY 1995 on focused environmental technology R&D, demonstrations, and commercialization. The lion's share was for R&D. The CENR data also identifies sizable NOAA expenditures for R&D in which environmental technology was a contributing objective. Because pro rating was not done, those numbers are not included here.

NOAA both develops and uses environmental monitoring technology. Its central weather forecasting function relies on both space based and in situ measurements of atmospheric water content, soil moisture, winds, clouds and precipitation. NOAA's weather forecasting research has grown in scope to include technologies to measure, model, and assess changes in the global environment. NOAA is working toward a goal of establishing

[2] Department of Commerce, *To Ensure the Nation's Future: Sustainable Development and the U.S. Department of Commerce,* A Draft Policy for Public Comment, Washington, DC, undated.

environmental observation, assessment, and prediction networks worldwide. This could require significant R&D investment and commercializing new environmental sensors to assess environmental conditions.

NOAA supports R&D on monitoring and remediation technologies to address marine and coastal area environmental degradation, reflecting its coastal zone management and fisheries habitat missions. It also supports fisheries research and management to develop technologies to reduce environmental degradation, such as fishing gear that is less harmful to the physical environment and that reduces wasteful bycatch and harm to protected species such as dolphins and various turtles.

NOAA classifies some R&D activities related to marine biotechnology as support for crosscutting initiatives on environmental technology. The R&D supports, among other things, development of molecular technologies for using marine organisms in applications such as aquaculture and bioremediation. About $14 million is expected to be spent on this and similar R&D in FY 1995.

National Institute of Standards and Technology

NIST missions include fundamental research and national standards measurement. In 1988, Congress explicitly authorized NIST to aid industry in "developing technology to improve product quality; to modernize manufacturing processes; to ensure product reliability; and to facilitate rapid commercialization of products based on new scientific discoveries."

NIST programs contribute to the development and application of technology, measurements, and standards across broad areas. Under NIST's environmental initiative, several R&D areas are targeted, including waste assessment and avoidance, advanced measurement and characterizing technologies for atmospheric pollutants and nonionizing radiation, and development of technologies needed for hazardous and radiation contaminated wastes.[3]

NIST estimates that its environmental technology R&D amounted to $ 8.5 million in focused activities in FY 1994, and may amount to $ 15.5 million in FY 1995. Additional amounts were also spent on R&D for which environmental technology was a contributing factor.

NIST Laboratories: NIST has eight laboratories with broad capabilities in the following areas:

- chemical science and technology,
- physics,
- electronics and electrical engineering,
- materials science and engineering,
- manufacturing engineering,
- computer systems,
- computers and applied mathematics, and
- building and fire research.

Most of the laboratories conduct R&D pertinent to environmental technologies. For example, the Chemical Science and Technology Laboratory has programs pertinent to pollution prevention and waste reduction technologies: chemical reactor engineering, separations using membranes, destruction of organic compounds in fluidized-bed reactors, and reactions in supercritical fluids. NIST's work is often supported in part by other federal agencies or industry. For example, in FY 1992, these projects were funded through a $315,000 appropriation to NIST and $170,000 in support from other federal agencies, mostly from the Air Force and the Department of Energy.

NIST's Green Buildings Program includes laboratory research, demonstrations, and funding for development of concepts and prototypes by industry. Improving energy efficiency is an important objective.

The NIST laboratories also have evaluated data and provided technology, measurement methods, sensors, and Standard Reference Materials (SRMs) used for industrial process design and

[3] For discussion of NIST activities, see National Institute of Science and Technology, "Environmental Technology at NIST," mimeo, April 1995.

control, waste minimization and processing, and environmental monitoring.

NIST has developed over 100 SRMs (which help assure accuracy of measuring systems and equipment) that are certified for concentrations of environmental contaminants. Laboratories use the SRMs in calibrating instruments to monitor atmospheric pollutants, gas mixtures, soils, and rainwater.

Advanced Technology Program: Begun in 1990, ATP provides R&D grants on a cost-shared basis with U.S. firms on high-risk, precommercial, generic technologies with commercial potential. Small, medium, and large companies, and joint ventures led by two or more companies, can compete for direct funding. Universities, federal laboratories, and nonprofit institutions often participate as subcontractors or members of joint ventures (although nonprofit institutions may administer joint ventures). ATP's mission—support for civilian technologies deemed to be in the nation's competitive interest—has become the subject of considerable controversy in Congress among those who think the federal government should not fund commercially oriented R&D.

ATP conducts both general and focused R&D competitions. Some of the awards in the general competition support research that could have energy efficiency or environmental benefits. For example, one grant recipient seeks to explore several options for improving the properties of biodegradable plastics while maintaining their biodegradability. Another recipient seeks to develop a biocatalytic process to remove sulfur from crude oil at an early stage—an approach that might reduce industry costs for environmental compliance.

Two focused competitions now under consideration also could have significant environmental implications: one is for vapor compression refrigeration technology; the other is for catalysis and biocatalysis technologies.

Manufacturing Extension Partnership: Although not a R&D program, MEP is working to foster a network of locally based organizations that help small manufacturing firms upgrade equipment, improve processes, and strengthen their business performance. These organizations, either Manufacturing Technology Centers (MTCs) or smaller Manufacturing Extension Centers (MECs), are nonprofit organizations. Most of the centers include environmentally conscious manufacturing as a component of their services. One center, the Pollution Prevention Center in Santa Monica, California, is particularly focused on this area.

NIST and EPA are jointly funding a MEP environmental partnership, announced in January 1995, to support development of methods to integrate environmental services with other MEP services as well as pilot centers focusing on specific industry sectors. Some MEP centers are funded by NIST. Other MEP centers are funded through the Department of Defense's Technology Reinvestment Project.

H.R. 2076, as reported by the House Committee on Appropriations in the 104th Congress, proposes a significant reduction in NIST's science and technology activities compared with FY 1995. Most of the reductions would occur in the ATP program and MEP. A slight reduction compared with FY 1995 is proposed for NIST's "core program" laboratories.

DEPARTMENT OF AGRICULTURE (USDA)[4]

USDA reports environmental technology RD&D budgets of $237 million for FY 1993 and nearly $250 million for 1994.[5] (See table 6-1). This esti

[4] A discussion of agroenvironmental R&D can be found in U.S. Congress, Office of Technology Assessment, *Agriculture, Trade, and Environment: Achieving Complementary Policies*, OTA-ENV-617 (Washington, DC: U.S. Government Printing Office, May 1995). For an in-depth examination of new agricultural technologies, including environmental aspects, see U.S. Congress, Office of Technology Assessment, *A New Technological Era for American Agriculture*, OTA-F-474 (Washington, DC: U.S. Government Printing Office, August 1992).

[5] U.S. Department of Agriculture, unpublished data, June 26, 1995.

TABLE 6-1: Estimated USDA Support for Environmental Technology RD&D ($ millions)

Category	FY 1993	FY 1994	FY 1995
Pollution avoidance	66.8	69.5	73.4
Pollution control	29,1	30.4	30.8
Monitoring and assessment	43.4	46.8	48.5
Remediation and restoration	89.0	93.0	91.9
Scaleup and commercialization (all categories)	8.4	8.7	11.0
Total	**236.7**	**246.4**	**255.6**

SOURCE: U.S. Department of Agriculture, unpublished data, June 26, 1995.

mate seems large relative to USDA's total R&D budgets of about $1.5 billion and when compared to another USDA estimate that 11.8 percent ($351 million) of *total federal and state* agricultural research expenditures of $2.97 billion was dedicated to environment and natural resources in 1993.[6] This latter estimate includes basic scientific as well as technological research. Furthermore, natural resources R&D is not necessarily aimed at improving environmental performance. However, it is possible that some environmentally favorable technological R&D might have been categorized under other headings such as crops, animals, forestry, and resources and technology.

Despite categorization of R&D as pollution avoidance, control, monitoring and assessment, or remediation and restoration. it is unclear what portion of the $250 million USDA reports as environmental technology R&D is tightly linked to technologies to prevent, control. and repair environmental damage. It may be that technologies and methods for studying water. soil. range, and forest resources that indirectly contribute to prevention, control, and remediation technologies are also included. Also complicating attempts to identify environmental technology R&D per se is the fact that a number of technologies for increasing animal and plant productivity may have environmentally favorable attributes (e.g., pest resistant plants require less pesticide application).

The Agricultural Research Service (ARS); Cooperative State Research, Education, and Extension Service (CSREES); and U.S. Forest Service (USFS) are the major supporters of environmental technology R&D within the department. (See Table 6-2). ARS and CSREES support RD&D pertinent to environmental problems associated with pest control, fertilizers, soil erosion and sediments, water and energy use, and animal and food processing wastes. Examples of relevant technologies include pest resistant vari-

TABLE 6-2: Estimated USDA Support for Environmental Technology RD&D by Agency[a] ($ millions)

Agency	FY 1993	FY 1994
Agricultural Research Service	109.0	113.7
Cooperative State Research Service[b]	49.1	55.4
Forest Service	68.4	69.0
Economic Research Service	1.4	1.4
Soil Conservation Service[c]	1.5	1.5
Alternative Agricultural Research and Commercialization Center[d]	**7.3**	**7.4**
Total	**236.7**	**248.8**

[a] Includes support for commercialization and scaleup activities
[b] Now part of the Cooperate State Research, Education, and Extension Service
[c] Now part of the Natural Resources Conservation Service
[d] Now part of the Rural Business and Cooperative Development Service

SOURCE: U.S. Department of Agriculture, unpublished table, June 26, 1995

[6] Office of Management and Budget, *Budget of the United States Government: Fiscal Year)996* (Washington, DC: U.S. Government Printing Office, 1995), T. 7-1, p. 94; and U.S. Department of Agriculture, Cooperative State Research Service, Inventory of Agricultural Research, Fiscal Year 1993, Washington, DC, 1993, in U.S. Congress, Office of Technology Assessment, *Agriculture, Trade, and Environment: Achieving Complementary Policies*, OTA-ENV-617 (Washington, DC: U.S. Government Printing Office May 1995), figure 2-9, p. 43.

eties, integrated pest management and biological pest controls, wastewater treatment, waste management and recycling, precision application of inputs, improved food and fiber processing, and cultural techniques to reduce erosion and chemical inputs.

USDA agencies also support RD&D for alternative crops and uses for agricultural commodities that in some cases may have environmental benefits. For instance, CSREES has worked on crop based alternatives for transmission fluid and diesel fuel, plant based anti-barnacle and anti-termite agents, and kenaf as an alternative fiber source for paper production, among others.[7] Biomass energy RD&D is also supported by the Department. The Alternative Agricultural Research and Commercialization Center (AARC, part of the Rural Business and Cooperative Development Service) spent $7.4 million in FY 1994 to help commercialize alternative uses that USDA claims are environmentally preferable.

The USFS reportedly spent $69 million in FY 1994 for environmental technology RD&D. However, a much smaller program (about $13 million) was identified when OTA asked the agency about RD&D programs directly linked to technologies for environmental damage prevention, control, and remediation.[8] The agency noted two major components: 1) biologically based pest control and bioremediation research (about $5 million annually during FY 1993 and 1994), and 2) technologies for effective use of wood (about $8 million annually). The wood use component includes "light on the land" harvesting and vegetation management, bio-based wood processing, improving wood and wood product recycling, and new applications of wood and processing wastes as adhesives, chemicals, and other materials.

The Natural Resources Conservation Service, which incorporates the former Soil Conservation Service, does pertinent work on soils; grazing practices and erosion control; stabilization and conservation of land, streams, and wetlands; and animal waste management and runoff pollution.

Other agencies such as the Animal and Plant Health Inspection Service and the Food Safety and Inspection Service (FSIS) do modest amounts of environmental technology R&D linked to their regulatory missions. For instance, FSIS spent between $150,000 to $200,000 in 1993 for hazardous waste reduction RD&D for laboratory operations.[9] The Economic Research Service performs economic and policy research on environmental aspects of agriculture.

In short, USDA reports itself as one of the largest federal supporters of environmental technology RD&D. However, the Department may construe environmental technology quite broadly to encompass production technologies, management practices, resource studies, and other activities that may be indirectly or secondarily linked to prevention, control, and reversal of pollution and environmental degradation. On the other hand, as in other areas, some of the most important environmental improvements in agricultural and forestry are likely to come from environmentally preferable attributes integrated into production systems, including management practices and techniques, rather than being embodied in discrete environmental protection hardware.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA) AND FEDERAL AVIATION ADMINISTRATION (FAA)

NASA, according to Clinton Administration estimates, has the second largest environmental technology RD&D budget among federal agen-

[7] D. Kugler, Cooperative State Research, Education, and Extension Service, U.S. Department of Agriculture, Washington, DC, personal communication, May 8, 1995.

[8] J. Sesco, Forest Service, U.S. Department of Agriculture, Washington, DC, letter, May 5, 1995.

[9] Ball & Associates, "Programs That Support Development and Diffusion of Innovative Environmental Technologies," contractor report prepared for Office of Technology Assessment, U.S. Congress, Washington, DC, December 1994, p. I-26.

cies—$791.1 million in FY 1994.[10] However, the overwhelming majority of the funding—$638.4 million in FY 1994 and $810.8 million in FY 1995—is for monitoring and assessment activities associated with Mission to Planet Earth and the Earth Observing Data Information System. Such activities—including satellite, aircraft, and balloon borne monitoring, and modeling and data management—focus on improving the understanding of Earth's major biological, chemical, and physical systems including atmospheric and ocean processes (e.g., ozone layer depletion and global climate change). OTA has not included these activities in its identification of federal agency environmental technology expenditures.

NASA supports substantial R&D for prevention and control of pollution. According to estimates of the NSTC's Joint Subcommittee on Environmental Technology (JSET), NASA spent $152.7 million on pollution avoidance and control in FY 1994.[11] For FY 1995, $180.5 million were budgeted for those categories.

The agency provided OTA with budget data on direct R&D for aircraft emissions reduction and noise reduction.[12] (See table 6-3). This R&D is performed by NASA's Office of Aeronautics under the High-Speed Civil Transport and Advanced Subsonic Technology programs.[13] JSET's estimate of NASA's pollution avoidance and control R&D budget are higher than that presented in the table because of inclusion of energy efficiency research and, perhaps, studies on atmospheric chemistry and air transport scenarios pertinent to emissions and noise reduction but not directly involving engine development.

TABLE 6-3: NASA Funding for Aircraft Emissions and Noise Reduction ($ millions)

Category	FY 1994	FY 1995	FY 1996 request
Emissions reduction	41	49	33
Noise reduction	58	54	42
Total	**99**	**103**	**74**

SOURCE: National Aeronautics and Space Administration, May 5,

The FAA also funds relevant research. That agency's environmental technology R&D budget included $1.3 million for noise reduction in FY 1994, rising to $1.4 million each for FY 1995 and FY 1996 request. Emissions reduction R&D had no funds in FY 1994 but is $200,000 for FY 1995 with the same amount requested for FY 1996.[14] FAA R&D funding is closely coordinated with NASA's through interagency agreement.

NATIONAL SCIENCE FOUNDATION

The National Science Foundation supports basic and applied research performed by individual investigators and groups of researchers, primarily at universities, through a peer-review system of selection based on merit. A portion of NSF support is directed at environmental technology R&D in cooperation with other federal research agencies, state agencies, nonprofit organizations, and universities through several programs. Four of these programs are:

[10] National Science and Technology Council, Joint Subcommittee on Environmental Technologies of the Committee on Environment and Natural Resources and Committee on Civilian Industrial Technologies, Washington, DC, unpublished data, Apr. 6, 1994.

[11] National Science and Technology Council, Joint Subcommittee on Environmental Technologies of the Committee on Environment and Natural Resources and Committee on Civilian Industrial Technologies, Washington, DC, unpublished data, Apr. 6, 1994.

[12] M. Fritz, Office of Resources and Management Systems, National Aeronautics and Space Administration, Washington, DC, letter and fax, May 5, 1995.

[13] For further discussion of aviation R&D including environmental issues see, U.S. Congress, Office of Technology Assessment, *Federal Research and Technology for* Aviation, OTA-ETI-610 (Washington, DC: U.S. Government Printing Office, September 1994).

[14] T. Connor, Office of Energy and Environment, Federal Aviation Administration, Washington, DC, personal communication, May 1, 1995.

- Environmentally Benign Chemical Synthesis and Processing Program;
- Environmentally Conscious Manufacturing Program;
- Technology For a Sustainable Environment Program; and
- NSF Industry-University Cooperative Research Centers (IUCRCs), and Engineering Research Centers (ERCs).

In 1992, NSF established the Environmentally Benign Chemical Synthesis and Processing Program in partnership with the chemical industry's Council for Chemical Research, in order to stimulate pollution prevention R&D at universities.[15] Industrial participation in the research is required, although the universities retain intellectual property rights consistent with the Bayh-Dole Act of 1980 (Public Law 96-512). In FY 1994, NSF supported this program with approximately $2.8 million of research grants to 29 separate grantees.[16]

Through the Environmentally Conscious Manufacturing Program, NSF supports research on cleaner raw material processing, use, and disposal. In FY 1995, this program received $8 million, which includes matching funds from the NSF Opportunity Fund, to investigate cleaner manufacturing technologies at universities, with a pollution prevention emphasis. Approximately 10 percent of this $8 million budget supports research that does not qualify as environmental technology R&D per se.[17] This program also builds on NSF experience in the Environmentally Benign Chemical Synthesis and Processing Program.

As noted in chapter 5, NSF cooperates with EPA to support the Partnership for Environmental Research. This partnership is part of the Administration's Environmental Technology Initiative (ETI), and includes the Technology For a Sustainable Environment Program. The goal of the Technology For a Sustainable Environment Program is to advance the development and use of technologies that avoid environmental damage. This Program is slated to award up to $6.5 million in FY 1995 for pollution prevention related R&D.[18] The focus of the Program's R&D includes support for small businesses, manufacturing operations in a variety of industries, clean chemical processing, and green materials manufacturing.

In addition, NSF supports IUCRCs and ERCs at universities, some of which perform environmental technology related R&D. The IUCRCs and ERCs were established to promote crossdisciplinary research, with the broad participation of industry, state government agencies, and universities. Funding for the centers ranges from approximately $1 million to $3.2 million annually.[19] Some IUCRCS and ERCs conduct environmental technology R&D, while others perform a portion of their research on environmentally related topics. For example, the Advanced Combustion

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[15] I. Amato, "The Slow Birth of Green Chemistry," *Science* 259:1538-1541, 1993.

[16] Information provided by the Division of Chemistry and Chemical & Transport Systems, U. S. National Science Foundation, Washington, DC, May 1995.

[17] Information provided by the Division of Design, Manufacture, and Industrial Innovation, U.S. National Science Foundation, Washington, DC, May 1995.

[18] National Science Foundation and Environmental Protection Agency, "Interagency Announcement of Opportunity: NSF-EPA Partnership for Environmental Research," Feb. 24, 1995, mimeo.

[19] Ball & Associates, "Programs That Support Development and Diffusion of Innovative Environmental Technologies," contractor report prepared for the Office of Technology Assessment, U.S. Congress, Washington, DC, December 1994.

ERC, jointly operated at Brigham Young University and the University of Utah, performs R&D directly relevant to environmental technology.[20], [21]

Department of the Interior

The Department of the Interior supports many research programs relating to the environment. Environmental research is an objective of several programs operated by the U.S. Geological Survey, the National Biological Service, the Bureau of Land Management, the Fish and Wildlife Service, and the National Parks Service. Most of these programs focus on assessment and monitoring of environmental conditions, ecosystems, and wildlife. While some observers might classify these programs as supporting environmental technology R&D, such a broad classification is not employed here. This chapter includes a brief description for those Department of Interior programs that explicitly focus on environmental technology R&D.

Bureau of Mines

The Bureau of Mines (BOM) is a research and fact finding agency responsible for helping to ensure an adequate supply of nonfuel minerals to meet U.S. needs. For example, the BOM supports research to provide technology to more safely extract, process, use, and recycle nonfuel minerals at a reasonable cost and with less environmental damage. OTA calculates that, in FY 1994, the BOM supported at least $40 million in focused environmental technology R&D through the Environmental Technology; Health, Safety, and Mining Technology; and the Minerals and Materials Science Programs.[22]

BOM supports environmental technology R&D and remediation through four budget line-item programs. These items and corresponding fiscal year 1994 funds are listed in the budget as environmental remediation ($26.8 million), pollution prevention and control ($27.3 million), health and safety ($48.2 million), and materials research partnerships ($8.2 million).[23] However, these budget items include moneys allocated for remediations at test sites, operations, administration, and other functions not directly related to R&D. Most BOM environmental technology R&D is conducted at nine BOM field research centers, and is administered within the Division of Environmental Technology. The Division oversees research in metallurgical waste, subsidence and solid waste, hazardous waste, biotechnology, hydrology, blasting, acid mine drainage, and water treatment systems. [24] The Division of Health, Safety and Mining Technology also administers some environmental technology R&D.

Some in Congress favor elimination of the Bureau of Mines. The House Appropriations Committee, for example, has recommended that the bureau be terminated in FY 1996, with funds available only for close out and environmental cleanup.[25]

Bureau of Reclamation

The Bureau of Reclamation, another agency in the Department of Interior, performs some environ-

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[20] Ibid.

[21] U.S. Congress, Office of Technology Assessment, *Industry, Technology, and the Environment: Competitive Challenges and Business Opportunities*, OTA-ISC-586 (Washington, DC: U.S. Government Printing Office, January 1994).

[22] National Science and Technology Council, Joint Subcommittee on Environmental Technologies of the Committee on Environment and Natural Resources and Committee on Civilian Industrial Technologies, Washington, DC, unpublished data, Apr. 6, 1994.

[23] Office of Management and Budget, *Budget of the United States Government: Fiscal Year 1996* (Washington, DC: U.S. Government Printing Office, 1995).

[24] Ball & Associates, "Programs That Support Development and Diffusion of Innovative Environmental Technologies," contractor report prepared for the Office of Technology Assessment, U.S. Congress, Washington, DC, December 1994.

[25] Committee on Appropriations, House of Representatives, U.S. Congress, *Department of Interior and Related Agencies Appropriations Bill, 1996*, House Report 104-173, June 30, 1995, p. 48.

mental technology R&D related to water pollution, through several programs performed both in the Bureau, by contractors, and at universities. The programs and their corresponding funding levels for FY 1994 are:

- Water Technology and Environmental Research Program (WATER) received approximately $2 million for environmental technology R&D;
- Water Treatment Technology Program (WTT) received $925,000 for environmental technology R&D; and
- Watershed Modeling Systems Initiative (WMSI) received $500,000 for environmental technology R&D.[26]

DEPARTMENT OF HEALTH AND HUMAN SERVICES

National Institute of Environmental Health Sciences

The Public Health Service of the Department of Health and Human Services supports some environmental technology R&D at the National Institute of Environmental Health Sciences (NIEHS), which is part of the National Institutes of Health. Through the Superfund Basic Research Program, NIEHS currently supports R&D at 29 universities and other extramural grantee institutions.[27] It supports basic and applied R&D on technologies to reduce and monitor exposure to toxic substances through, for example, bioremediation, combustion, supercritical wet oxidation, and steam injection to remove solvents from soils. The NIEHS Superfund Basic Research Program budget for FY 1994 was approximately $33 million.[28] Of this FY 1994 budget, the Clinton Administration estimates that $10.9 million supported directly relevant environmental technology R&D.[29] One important aspect of the Program is its interdisciplinary nature. The R&D bridges biotechnology, engineering, hydrogeology, and ecological sciences in a way that emphasizes long-term integrated basic research of the remediation of hazardous wastes.

Established by the Superfund Amendments and Re-Authorization Act of 1986 (Public Law 99-499), the Superfund Basic Research Program at NIEHS was intended to complement existing activities within EPA and the Agency for Toxic Substances and Disease Registry.[30] One of the key characteristics of the Program is the fundamental nature of the research it supports. According to NIEHS sources, many projects funded through the Program lead to further R&D performed by other agencies, such as the Department of Energy, on a much larger scale.[31] In some cases involving other federal research laboratories, the R&D conducted under the Superfund Basic Research Program has lead to cooperative research and development agreements (CRADAs) with nonfederal research partners.[32]

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[26] Ibid.

[27] Ball & Associates, "Programs That Support Development and Diffusion of Innovative Environmental Technologies," contractor report prepared for the Office of Technology Assessment, U.S. Congress, Washington, DC, December 1994.

[28] B. Anderson, Superfund Basic Research Program, National Institute of Environmental Health Sciences, Department of Health and Human Services, Research Triangle Park, NC, personal communication, May 1995.

[29] National Science and Technology Council, Joint Subcommittee on Environmental Technologies of the Committee on Environment and Natural Resources and Committee on Civilian Industrial Technologies, Washington, DC, unpublished data, Apr. 6, 1994.

[30] Ball & Associates, "Programs That Support Development and Diffusion of Innovative Environmental Technologies," contractor report prepared for the Office of Technology Assessment, U.S. Congress, Washington, DC, December 1994.

[31] B. Anderson, Superfund Basic Research Program, National Institute of Environmental Health Sciences, Department of Health and Human Services, Research Triangle Park, NC, personal communication, May 1995.

[32] Ibid. A fuller treatment of CRADAs is explored in the context of the DOE National Laboratories as part of chapter 3.