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Report to Congressional Committees

June 2009

TECHNOLOGY TRANSFER

Clearer Priorities and Greater Use of Innovative Approaches Could Increase the Effectiveness of Technology Transfer at Department of Energy Laboratories

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GAO-09-548

June 2009

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Highlights

Highlights of GAO-09-548, a report to congressional committees

Why GAO Did This Study

The Department of Energy (DOE) spends billions of dollars each year at its national laboratories on advanced science, energy, and other research. To maximize the public's investment and to foster economic growth, federal laws and policies have encouraged the transfer of federally developed technologies to private firms, universities, and others to use or commercialize. The American Recovery and Reinvestment Act of 2009 further emphasized the role of such technologies for addressing the nation's energy, economic, and other challenges.

Congress requested GAO to examine (1) the nature and extent of technology transfer at DOE's laboratories; (2) the extent to which DOE can measure the effectiveness of its technology transfer efforts; and (3) factors affecting, and approaches for improving, DOE's efforts. GAO analyzed documents and data and spoke with officials at DOE headquarters and all 17 DOE national laboratories.

What GAO Recommends

GAO is recommending a number of actions, including that DOE articulate departmental priorities and a definition for technology transfer, improve its performance data, and ensure that laboratories have sufficient expertise and a systematic approach for identifying their commercially promising technologies. In commenting on a draft of this report, DOE generally agreed with the findings but did not comment on the recommendations.

View GAO-09-548 or key components.
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What GAO Found

Although DOE's laboratories routinely share their technologies, capabilities, and knowledge with outside entities, it is difficult to assess the full extent of technology transfer efforts because policies defining technology transfer are unclear and headquarters and laboratory officials do not always agree on which activities should be included. Certain activities performed for or with private companies, universities, and state or local governments are widely regarded as technology transfer, including (1) performing research on behalf of or in collaboration with these entities; (2) licensing the laboratories' existing technologies for such entities to use or commercialize; and (3) allowing these entities access to the laboratories' unique facilities and equipment for their own research. Successful technology transfer efforts have focused on a variety of areas ranging from cancer treatment to biofuels. DOE and laboratory officials do not agree, however, on whether research sponsored by other federal agencies should be considered technology transfer, and DOE's policies are unclear on this. Although work for other federal agencies—worth about $1.8 billion in 2008—may result in technologies that are eventually transferred to the marketplace, in the short run, the work entails sharing federal research and technologies with other federal agencies for noncommercial aims.

DOE cannot determine its laboratories' effectiveness in transferring technologies outside DOE because it has not yet established departmentwide goals for technology transfer and lacks reliable performance data. The Energy Policy Act of 2005 required DOE to establish goals for technology transfer and provide Congress its implementation plan no later than February 2006; DOE has not yet done so. While some DOE laboratories and program offices have begun articulating their own technology transfer goals, these vary widely. In addition, DOE performance data on technology transfer activities are problematic because data accuracy and completeness are questionable.

A number of factors can constrain the extent to which DOE laboratories transfer their technologies, although some are using approaches to help increase the likelihood that promising technologies will be commercialized. Officials at the 17 laboratories identified three primary challenges: (1) competing staff priorities or gaps in expertise needed to consistently identify promising technologies or potential markets; (2) lack of funding to sufficiently develop or test some promising technologies to attract potential partners; and (3) lack of flexibility to negotiate certain terms of technology transfer agreements. Some laboratories have used innovative approaches, such as inviting entrepreneurs to evaluate their research and commercialize a technology or tapping into outside funding for the additional development needed to attract commercial interest. Approaches used by other federal laboratories may offer additional ways for DOE to improve its technology transfer. These efforts are especially important given the goals of American Recovery and Reinvestment Act of 2009 and the additional funding provided to DOE to meet those goals.

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Abbreviations

CRADA	Cooperative Research and Development Agreement
DOE	Department of Energy
NNSA	National Nuclear Security Administration

United States Government Accountability Office
Washington, DC 20548

June 16, 2009

The Honorable Byron Dorgan
Chairman
The Honorable Robert Bennett
Ranking Member
Subcommittee on Energy and Water Development
Committee on Appropriations
United States Senate

The Honorable Peter J. Visclosky
Chairman
The Honorable Rodney P. Frelinghuysen
Ranking Member
Subcommittee on Energy and Water Development
Committee on Appropriations
House of Representatives

Since the 1940s, the Department of Energy's (DOE) national laboratories and specialized research facilities have played a central role in pushing the research frontiers of physics and other basic sciences and applying this knowledge to developing technologies.[1] Over the years, some of the research at these laboratories has contributed to the development of technologies—ranging from wind turbines to key components of computer microchips—that have benefited daily life, while creating opportunities for the businesses and investors that bring the laboratories' technologies to the marketplace. In the face of today's challenges, Congress and the administration, among others, have stressed the importance of science and technology in improving America's economy, moving to sustainable forms of energy, and protecting national and global security. Recent measures, including the American Recovery and Reinvestment Act of 2009, have underscored the federal role—DOE's in particular—in funding the scientific research to develop the technologies for meeting these challenges and bringing them into widespread use.

As one of the largest research agencies in the federal government, DOE spends billions of dollars each year on publicly funded research to support

[1]The Department of Energy, whose predecessors include the Atomic Energy Commission, was created in 1977 from diverse agencies.

its diverse missions, including energy development, energy efficiency, and nuclear security. Most of this research is carried out under DOE's direction and oversight by scientists, engineers, and others employed at DOE's 17 national laboratories, including its 16 contractor-managed and operated laboratories and 1 DOE-managed and operated laboratory. The results of this research may further science and, at the same time, hold commercial potential for addressing needs of businesses, governments, organizations, or individuals.

To maximize the return on the public's investment in research and to foster economic growth, federal policies have encouraged the transfer of federally developed technologies to private firms, universities, local governments, and others capable of benefiting themselves from the technologies or further expanding the technologies' benefits by bringing them into the marketplace. Laws such as the Stevenson-Wydler Technology Innovation Act of 1980 and the Bayh-Dole Act of 1980 have enabled federal laboratories to transfer their technologies and scientific capabilities by, for example, licensing the laboratories' technologies to outside entities or partnering with those entities on research and development projects. Subsequent laws have aimed to further expand technology transfer or to improve the technology transfer efforts of individual agencies. For instance, the Energy Policy Act of 2005 sought to improve the process for transferring technologies by requiring the Secretary of Energy to, among other things, appoint a technology transfer coordinator for the department and to develop technology transfer goals and a plan for implementing them.

While DOE is responsible for establishing technology transfer policies and overseeing performance, carrying out technology transfer activities is a responsibility of the laboratory staff operating DOE's laboratories. To accomplish technology transfer, these laboratory operators need to promote their laboratories' technologies and scientific capabilities to outside entities, identify potential partners, and negotiate technology transfer agreements.

In response to congressional direction in the explanatory statement accompanying the Consolidated Appropriations Act of 2008, this report examines (1) the nature and extent of technology transfer at DOE laboratories; (2) the extent to which DOE can measure the effectiveness of technology transfer efforts at its laboratories; and (3) factors affecting technology transfer and approaches that may have potential for improving technology transfer.

To conduct our work, we analyzed DOE's data on the extent of its technology transfer activities and contacted all 17 DOE national laboratories. To understand the nature, extent, and overall effectiveness of DOE's technology transfer efforts, we interviewed the officials responsible for coordinating the 17 laboratories' technology transfer activities, including visits to Lawrence Berkeley and Lawrence Livermore national laboratories in California and the Pacific Northwest National Laboratory in Washington state. Although we determined that DOE's technology transfer data were sufficiently reliable for selecting laboratories to contact or reporting aggregate numbers of technology transfer agreements, for verification purposes, we asked responsible laboratory and DOE officials about their efforts to ensure the data's reliability and obtained additional data from the laboratories on the nature and extent of their technology transfer efforts in fiscal years 2006 through 2008. We also obtained copies of technology transfer agreements, performance measurement plans, or other documentation of DOE and laboratory efforts to transfer technologies and measure technology transfer performance. And, we interviewed DOE headquarters officials in the Office of Laboratory Policy and Evaluation and the Office of the General Counsel, as well as members of DOE's Technology Transfer Policy Board and Technology Transfer Working Group, about the nature and effectiveness of DOE's technology transfer. In addition, to learn more about technology transfer from the nonfederal perspective, we interviewed representatives from industry and universities knowledgeable about technology transfer. Finally, to better understand how other federal agencies transfer technology, we interviewed Department of Defense officials who oversee technology transfer for that department's laboratories. A more detailed description of our scope and methodology appears in appendix I.

We conducted this work as a performance audit from July 2008 through June 2009, in accordance with general accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

DOE is responsible for a diverse set of missions, including nuclear security, environmental cleanup, and energy research. These missions are managed by DOE program offices, the largest of which include:

- National Nuclear Security Administration,[2] responsible for maintaining the nation's nuclear weapons stockpile and preventing nuclear proliferation;

- Office of Environmental Management, responsible for cleaning up wastes left from decades of nuclear weapons research and production;

- Office of Science, responsible for advancing fundamental research in physics and other sciences; and

- Offices of Energy Efficiency and Renewable Energy, of Fossil Energy, and of Nuclear Energy, responsible for energy research and energy technology development and deployment.

Overseen by these program offices, contractors carry out the day-to-day work of these missions at most of the 17 national laboratories and other facilities nationwide.[3] The contractors that manage and operate national laboratories include universities, private companies, nonprofit organizations, or consortia thereof. In addition to carrying out DOE-funded research, some of these contractors also manage DOE's national user facilities, located at the national laboratories, in which advanced scientific equipment or expertise are made available to researchers from outside DOE's laboratories.

Since the early 1980s, Congress has passed several laws related to technology transfer across the federal government. One of the foundational technology transfer laws, the Stevenson-Wydler Technology Innovation Act of 1980,[4] articulated technology transfer as a federal priority, requiring federal laboratories to establish an office of research and technology applications and devote budget and personnel resources to promoting technology cooperation and the transfer of federal technologies. Another key law, the Bayh-Dole Act of 1980, sought to promote the use and commercialization of federal technologies by

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[2]Although the National Nuclear Security Administration is a separately organized agency under DOE, unless otherwise specified, for purposes of this report, references to DOE or its program offices include the National Nuclear Security Administration.

[3]Unlike DOE's 16 contractor-managed-and-operated national laboratories, the National Energy Technology Laboratory in Oregon, Pennsylvania, and West Virginia, one of the 17 DOE national laboratories, is managed and operated by DOE itself. As a result, DOE employees—rather than employees of one of DOE's contractors—carry out this laboratory's technology transfer and other activities.

[4]Pub. L. No. 96-480, 94 Stat. 2311.

requiring federal agencies to assure small businesses, universities, and nonprofits the right to elect title to new inventions made under their federal funding agreements.[5] Other laws also authorize contractor- or federally operated government laboratories to perform collaborative research with universities, state or local governments, nonprofit organizations, or private industry. The National Competitiveness Technology Transfer Act of 1989[6] directed federal agencies to include provisions in their contracts that establish technology transfer as a mission of contractor-operated federal laboratories. In addition, some technology transfer laws pertain solely to DOE. For example, under the Atomic Energy Act of 1954[7] and the Federal Nonnuclear Energy Research and Development Act of 1974,[8] DOE may waive its claim to title to inventions that are made under a DOE contract. This authorizes DOE to allow the contractors that operate its laboratories to elect to retain title to inventions at their laboratories, obtain patents or other legal protections, and then license the inventions to others.[9]

Federal regulations and DOE's policies and guidance, including federal and DOE acquisition regulations, govern the implementation of activities authorized under the various technology transfer laws. These policies outline DOE's and contractors' responsibilities with respect to these activities and describe the general processes and guidelines under which DOE or its contractors may take ownership of discoveries made at the laboratories, license their intellectual property, or work with outside entities seeking to benefit from the laboratories' capabilities. DOE's technology transfer coordinator, most recently the Under Secretary for Science, is the principal advisor to the Secretary of Energy on all matters related to technology transfer and commercialization. DOE's Assistant General Counsel for Technology Transfer and Intellectual Property helps formulate DOE's intellectual property and technology transfer policies,

[5] Pub. L. No. 96-517, 94 Stat. 3015. Bayh-Dole also currently requires that the right to elect title to an invention was to be included in contracts with small business, universities, and nonprofits for the operation of federal laboratories. Prior to the enactment of Bayh-Dole, however, DOE's enabling legislation authorized the department to elect title and license its technologies to others.

[6] Pub. L. No. 101-189, 103 Stat. 1352.

[7] 42 U.S.C. § 2182.

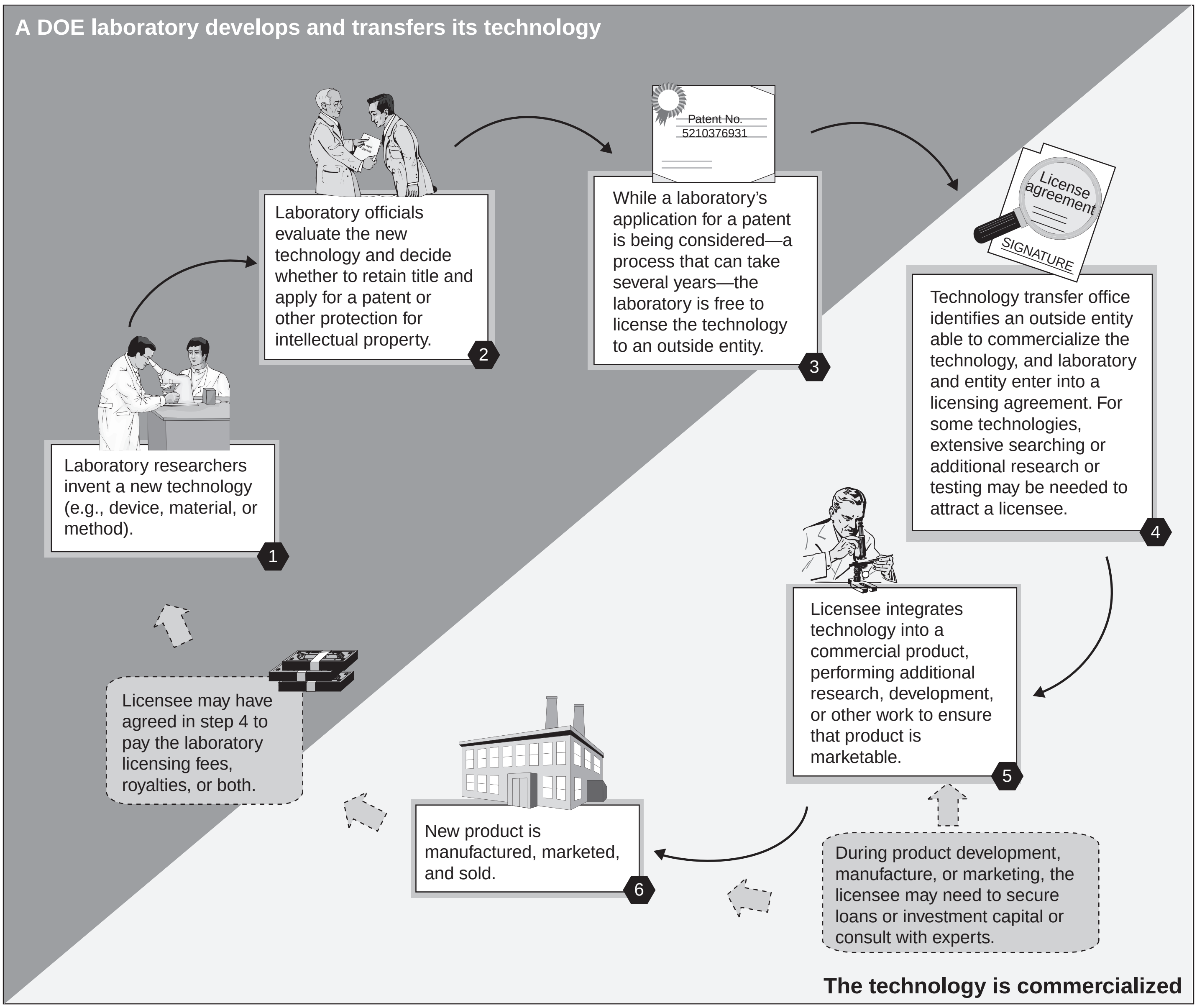
[8] 42 U.S.C. § 5908.

[9] A similar provision in the Bayh-Dole Act (35 U.S.C. § 202) applies throughout the federal government; however, it pertains only to small business and nonprofit contractors.

along with others in the department, and represents DOE's interests in matters involving intellectual property and technology transfer. The Technology Transfer Policy Board—comprising representatives from various DOE program and staff offices—supports the coordinator by recommending technology transfer policies and helping oversee technology transfer activities. Field-based officials, under the guidance of DOE program officials and the Office of the General Counsel, are responsible for directly overseeing laboratory contractors' technology transfer efforts to ensure that they comply with applicable laws, regulations, and DOE policies. In addition, DOE's Technology Transfer Working Group—comprising both federal and laboratory contractor employees—is responsible for supporting and advising the Technology Transfer Policy Board and sharing information on technology transfer opportunities and best practices.

The process of commercializing federal technologies generally begins with research and development efforts at federal laboratories, which result in new technologies that may have commercial potential. At each of DOE's laboratories, the office of research and technology applications (which, for our purposes, we refer to as the technology transfer office) is generally responsible for coordinating laboratories' efforts to identify technologies and obtain patents or other legal protections for those technologies. The office may also be responsible for promoting the laboratory's technologies to potential licensees, negotiating licensing or other agreements, or managing the laboratory's existing licenses and patents. Licensees are typically responsible for commercializing the licensed technologies by integrating the technologies into commercial products and overseeing the development, manufacture, and marketing of those products. Because technology commercialization can require significant financial resources or specialized skills, licensees, particularly small businesses or startup companies, may obtain help from venture capitalists or other outside experts. And, because the pathway from laboratory bench to commercial product is complex, involving numerous and sometimes difficult steps, the process can derail at any point and products may not always reach, or find success in, the marketplace (see fig. 1).

Figure 1: Process to Commercialize DOE Laboratory Technologies



Sources: GAO analysis of DOE and other information; Art Explosion (clip art).

DOE Laboratories Share Technologies and Capabilities, but Only Certain Activities Are Widely Regarded as Technology Transfer

DOE and Laboratory Officials Agreed That Four Key Types of Technology-Sharing Activities and Their Associated Agreements Are Technology Transfer

In addition to conducting research on behalf of DOE's missions, DOE's national laboratories routinely share their technologies, capabilities, and knowledge with outside entities by performing research, licensing the laboratories' technologies, and making their facilities and personnel available to others. Before carrying out many of these activities, the parties must first enter into agreements that spell out the terms and conditions for sharing the laboratories' technologies and capabilities. While DOE's laboratories may enter into agreements with a variety of outside entities working in areas ranging from health care to biofuels, only some of the laboratories' technology- and knowledge-sharing activities are widely considered to be technology transfer. Specifically, the technology transfer officials we spoke with at DOE's headquarters and the 17 national laboratories generally agreed that the following activities at DOE's laboratories and their associated agreements—if conducted in partnership with, or on behalf of, businesses, universities, state or local governments, or other nonfederal entities—constitute technology transfer:

- **Cooperative research and development agreements (CRADA):** Under these agreements, laboratory employees collaborate with nonfederal partners to carry out research projects that will directly benefit DOE program missions and the partners' research and development goals. Under a CRADA, a laboratory may contribute personnel, equipment, or other in-kind resources to a project, while its CRADA partners must contribute funds, in-kind resources, or both.[10] For example, the National Renewable Energy Laboratory in Colorado collaborated with

[10]DOE is not required to contribute in-kind resources toward a CRADA, nor may DOE funds flow to a CRADA partner. The partner, however, must contribute in-kind resources and—if DOE decides not to contribute any of its own resources—must fund any work performed by the DOE laboratory.

Sacramento's utility district on the design and construction of demonstration homes incorporating the laboratory's research on energy-efficient buildings. The work, which occurred under a CRADA, allowed the laboratory to field-test its research and helped the utility develop design specifications for energy-efficient homes, assisting builders and helping to meet statewide goals for improving buildings' efficiency. In fiscal years 2006 through 2008, all 17 of DOE's national laboratories entered into CRADAs with private firms, universities, state or local governments, nonprofit organizations, or other nonfederal partners. In fiscal year 2008, over 90 percent of the 689 CRADAs at the 17 laboratories were with private industry partners.[11]

- **Nonfederal work-for-others agreements:** Under a nonfederal work-for-others agreement, a DOE laboratory agrees to conduct research on behalf of a nonfederal sponsor. Although this research must be consistent with the laboratory's and DOE's missions and draw on the laboratory's unique capabilities, these agreements differ from CRADAs in that the research need not directly benefit DOE's programs. Consequently, the sponsor must pay the entire cost of a project done under these agreements. In turn, however, the sponsors typically may elect to receive ownership of any new intellectual property, including new inventions by laboratory employees, resulting from the research.[12] For example, Los Alamos National Laboratory in New Mexico, under a nonfederal work-for-others agreement with the University of California, Los Angeles, is developing key components of a detection and response system for avian flu, which will enable rapid DNA analysis of a large number of biological samples at multiple locations worldwide. Drawing on the laboratory's expertise in computer modeling and simulation, and using its patented biological

[11]Unless otherwise noted, data presented throughout this report on the number of the 17 laboratories' technology agreements, or the dollar amounts associated with those agreements, came from the data we collected from those laboratories in November 2008. See appendix I for additional details.

[12]If the work-for-others sponsor elects to receive ownership of any resulting laboratory inventions—effectively giving the sponsor exclusive authority to determine whether and for what purpose others can use the inventions—the sponsor must also grant the government a license to use the invention on behalf of the government. In contrast, ownership over laboratory inventions, made in whole or in part by laboratory employees, resulting from a CRADA is determined through negotiation between the laboratory and the CRADA partner. Regardless of any negotiated outcome, by law the CRADA partner always has the option to choose an exclusive license in a predetermined field of use for reasonable compensation. And, the federal government always retains full rights to use the inventions on behalf of the government, even if the invention was made solely by the nonfederal partner's employees.

analysis technologies, the laboratory will develop computer software and hardware, as well as analysis tools and protocols for detecting and responding to infectious disease outbreaks. All 17 of DOE's national laboratories had work-for-others agreements with nonfederal partners in fiscal years 2006 through 2008. In fiscal year 2008 alone, the laboratories participated in over 2,600 work-for-others agreements with nonfederal sponsors—65 percent of which were sponsored by private industry and 35 percent by universities, state or local governments, or other nonfederal sponsors.

- **Licensing agreements:** In addition to performing research, laboratories share their technologies by licensing their patented discoveries, copyrighted software programs, or other intellectual property to nonfederal entities seeking to use or commercialize those technologies. In some cases, the licensee agrees to pay fees or royalties to the laboratory in exchange for the laboratory's permission to use or commercialize a technology. For example, Ames Laboratory in Iowa and Sandia National Laboratories in California and New Mexico developed and patented a lead-free solder, which became popular after concerns emerged about potential risks posed by lead solder in electronics. As of July 2007, Ames laboratory was licensing or sublicensing the technology to 55 companies around the world, generating in fiscal year 2007 about $5 million in licensing income. In fiscal years 2006 through 2008, 16 of the 17 national laboratories had licensed their patented technologies to others, generating in 2008 about $44 million in fees and royalties.[13]

- **User-facility agreements:** Under a user-facility agreement, scientists from outside organizations can use DOE's unique scientific equipment for their own research, sometimes in collaboration with laboratory staff. Several of DOE's national laboratories are home to the department's user facilities. For example, the Center for Nanoscale Materials—an 88,000-square-foot user facility completed in September 2007 at Argonne National Laboratory in Illinois—makes customized laboratory space and specialized equipment available for research on materials and structures at the atomic, or nano, scale, with applications ranging from medicine to microchips. Some of the center's users are also allowed to access the Advanced Photon Source, another of Argonne's user facilities, for

[13]This $44 million includes only patent licenses with private industry. Although DOE's laboratories may have licensed their patented technologies to other nonfederal entities, such as universities, to reduce respondent burden, we limited the licensing data that we collected from the laboratories to focus exclusively on patented technologies licensed to private industry in fiscal year 2008. See appendix I for additional details.

nanoscience research using the photon source's ultrabright x-ray beams. Users may conduct their research at DOE's facilities for free or a negotiated cost, if the results of their research will be made public. The users who wish to keep their results private, however, must reimburse DOE for the full cost of using the facilities. According to DOE data for fiscal year 2008, DOE had more than 2,800 user-facility agreements for user facilities at 8 of the 17 laboratories.[14]

Successful examples of technology transfer cited by laboratory officials, often involving the use of multiple agreements, reflected research and development or technology commercialization efforts that led to or show promise for advancements in important areas ranging from medicine to fuel-efficient vehicles. For example:

- Lawrence Livermore National Laboratory in California transferred technology to a small medical manufacturing company seeking to develop and commercialize a medical device that could dramatically improve the effectiveness and reduce the costs of treating certain types of cancer. The new device, slated for use in a cancer treatment known as proton therapy—which doctors consider superior to other types of cancer therapy because cancerous cells can be more precisely targeted—is based on a miniaturized version of an atomic particle accelerator, which the laboratory had developed for testing nuclear weapons. According to Lawrence Livermore officials, if the development and commercialization efforts are successful, the device will shrink the size and cost of current proton therapy technology—from a basketball-court-sized machine weighing several hundred tons to a much smaller device 2 meters long and costing millions of dollars less—making the therapy more widely available. After performing initial research to verify that the weapons-testing technology could be adapted for cancer treatment, in 2007, the laboratory licensed the technology to the medical manufacturer and agreed to collaborate on additional research, resulting in a licensing agreement and a CRADA. Under the licensing agreement, the laboratory gave the company exclusive rights to make, use, or sell the laboratory's patented technology—limited, however, to the field of cancer therapy—and the company agreed to pay licensing fees and royalties to the laboratory. Under the CRADA, the laboratory and the company agreed to perform additional research and develop a full-scale prototype of the proton therapy device.

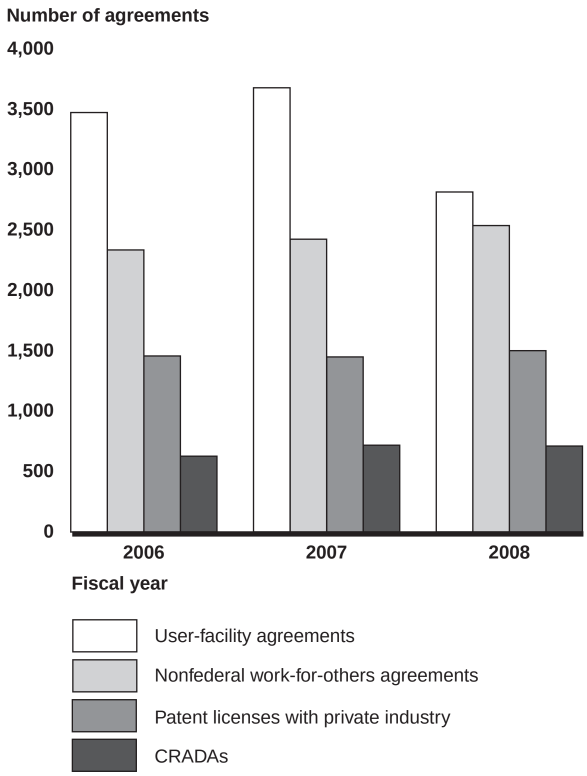
[14]Data on the number of user-facility agreements came from data collected annually by DOE headquarters.

- Pacific Northwest National Laboratory in Washington state entered into a patent license and multiple CRADAs with a major agricultural products company to develop and pilot-test technologies and processes for converting corn fibers or other corn materials into fuel (ethanol) or various industrial chemicals. If successful, the project will lay the groundwork for improving biorefineries' efficiency, enabling refineries to use a wider variety of corn materials—for instance, corn silk and husks rather than just kernels—and produce a wider variety of products more cost-effectively. The Pacific Northwest laboratory granted the company exclusive and nonexclusive royalty-bearing licenses to the laboratory's patented technologies and processes for isolating and converting sugars, such as those in corn materials, into other chemicals. Under a CRADA, funding from the company and DOE's Office of Energy Efficiency and Renewable Energy's Biomass Program are offsetting the laboratory's costs for conducting research on the sugar conversion process and other technical challenges.

- Lawrence Berkeley and Livermore national laboratories in California and Sandia National Laboratories have long-standing partnerships, resulting in multiple technology transfer agreements, with a consortium of major computer- and microchip-manufacturing companies, universities, and other organizations, working collaboratively on industrywide problems and managing risks and costs associated with the research and development and production of semiconductors. Because the industry's ability to increase computer speed and memory using current semiconductor technologies and production methods is reaching its limits, one of the consortium's efforts is to develop the next generation of mass-produced semiconductor, which, if successful, could result in computer chips that are 100 times faster and hold 1,000 times more memory than current chips, according to the industry consortium. Berkeley laboratory scientists are using the Advanced Light Source—a user facility at the Berkeley laboratory housing a powerful ultraviolet and x-ray source 1 billion times brighter than the sun—to develop and test a more precise method for etching paths into microchips that house the circuitry and other components. The technology transfer agreements involved include multiple nonfederal work-for-others agreements and an earlier CRADA.

The number of agreements associated with the four types of activities widely recognized as technology transfer—cooperative research and development, nonfederal work for others, licensing, and user-facility agreements—remained relatively stable from fiscal years 2006 through 2008 (see fig. 2). See appendix II for additional data on DOE's agreements.

Figure 2: DOE Laboratories' Technology Transfer Agreements, Fiscal Years 2006 through 2008



Source: GAO analysis of DOE data.

Note: Numbers of user-facility agreements come from data collected annually at DOE headquarters. All other numbers come from the 17 national laboratories, as part of our November 2008 data collection effort. See appendix I for additional details.

Lack of Clear Policies on What Constitutes Technology Transfer Complicates Assessment of Full Nature and Extent of Activities

Although DOE and laboratory officials generally agreed that CRADAs, nonfederal work for others, licensing, and user-facility agreements, constitute technology transfer, they did not agree on whether other routine activities—similarly aimed at sharing the laboratories' technologies, capabilities, or knowledge—also constitute technology transfer, and DOE policies do not provide a clear definition. In particular, DOE carries out a large body of work funded by other federal agencies under a type of agreement known as a federal work-for-others agreement. For example, the Department of Homeland Security has funded work at the Pacific Northwest National Laboratory that has drawn on the laboratory's expertise in areas such as radiation detection to develop passenger- and cargo-screening technologies for ports of entry.

In fiscal years 2006 through 2008, 16 of the 17 national laboratories conducted work under these agreements. DOE's laboratories had about 4,900 federal work-for-others agreements in fiscal year 2008, including about 600 funded by the Department of Homeland Security under an arrangement granting that agency priority access to staff and facilities at DOE's laboratories.[15]

Although technology transfer officials from 10 of the 17 laboratories said they consider federal work-for-others agreements to be technology transfer, the officials at several of the other laboratories—as well as representatives from DOE's Office of the Assistant General Counsel for Technology Transfer and the Technology Transfer Policy Board—told us that they do not, in part because the transfer involves another federal agency rather than private industry. This difference may stem from the fact that DOE's policies do not clearly define in all cases what activities and types of agreements constitute technology transfer, or the policies provide conflicting views. Specifically, the definitions of activities and agreements, such as CRADAs and technology licenses, which are considered to be technology transfer in DOE's acquisition regulations and a January 2008 policy statement on technology transfer by the Secretary of Energy[16] are broad enough to allow federal work-for-others agreements to fall under the department's definition of technology transfer. The January 2008 policy statement—which defines technology transfer as the process by which knowledge, intellectual property, or capabilities developed at DOE national laboratories are transferred to "any other entity, including private industry, academia, state, and local governments, or other government entities"—does not explicitly include or exclude work for other federal agencies. Likewise, DOE's acquisition regulations provide a broad definition that does not explicitly state whether federal work-for-

[15]The Homeland Security Act of 2002 (6 U.S.C. § 189) authorizes the Department of Homeland Security to access the capabilities of DOE's laboratories to further its own mission objectives. Under a memorandum of agreement between the two departments, DOE laboratories give research funded by the Department of Homeland Security equal priority for laboratory staff and facilities as DOE-funded research. Under DOE policy, work for all other federal agencies must not interfere with work for DOE or the Department of Homeland Security.

[16]*Secretarial Policy Statement on Technology Transfer at Department of Energy Facilities* (Jan. 31, 2008).

others is to be considered technology transfer.[17] In contrast, a DOE policy directive reissued in 2003, which aimed to improve various aspects of DOE's "technology partnering" activities, identified work for nonfederal entities as one of the activities covered by the directive, but the covered activities did not include federal work-for-others.[18] We did not identify any law or policy specifically stating that DOE may not consider work for other federal agencies to be technology transfer. Nevertheless, laws and policies emphasize the federal government's role in transferring technology to nonfederal entities. For example, the Stevenson-Wydler Act states that its purpose is "stimulating improved utilization of federally funded technology developments…by State and local governments and the private sector," and Executive Order 12591 requires all agencies to "assist in the transfer of technology to the marketplace."

Although nonfederal entities may ultimately commercialize the results of federal work-for-others projects, in the short run these projects involve making federal capabilities available to other federal agencies for noncommercial aims. Under a federal work-for-others agreement with the U.S. Department of Transportation, researchers at Argonne National Laboratory, for example, developed a system for detecting and responding to chemical attacks in confined, populated spaces, such as buildings and subway tunnels. Developed by the laboratory's Decision and Information Sciences Division in the wake of the 1995 sarin gas attack on the Tokyo subway, the technology integrates chemical detectors, closed-circuit televisions, advanced computer modeling of chemical dispersion, and other components to provide early warning of likely chemical attacks and recommend an appropriate response. According to Argonne laboratory officials, the system was demonstrated and is currently operating in the

[17]Department of Energy Acquisition Regulation section 970.5227-3, "Technology Transfer Mission," defines technology transfer activities as "including but not limited to: identifying and protecting intellectual property made, created, or acquired at or by the laboratory…negotiating all aspects of and entering into CRADAs; providing technical consulting and personnel exchanges; conducting science education activities and reimbursable work for others; providing information exchanges; and making available laboratory or weapon production user facilities."

[18]The directive, DOE Order 482.1, "DOE Facilities Technology Partnering Programs" aimed to ensure that DOE's technology partnering activities are carried out efficiently, are consistent with applicable laws, and receive proper review and oversight. The activities and agreements covered under the directive include CRADAs; nonfederal work-for-others, technology licensing, and user-facility agreements; activities to identify and protect intellectual property; technical consulting; and personnel exchanges.

Washington, D.C., and Boston subways, among other places, and it has been licensed to a large company for commercialization.

Laboratory and DOE officials identified still other activities as technology transfer, although again there was little agreement. For example, officials at 11 of the laboratories said that they consider publishing or presenting research findings to be technology transfer. Technology transfer officials from the Fermi National Accelerator Facility in Illinois said that while publications and presentations are not formally tracked as part of the laboratory's technology transfer efforts, these activities are commonplace at the laboratory—in fiscal year 2007 alone, the laboratory had 285 journal publications and 450 presentations at conferences—and involve sharing the laboratory's knowledge with others. Officials at the other laboratories, in contrast, did not specifically identify publishing or presenting research to be technology transfer. Officials at the Pacific Northwest and Sandia national laboratories told us they considered their laboratories' economic development programs, in which laboratory personnel provide technical advice to local small businesses, to be technology transfer. Technology transfer officials at 5 other laboratories agreed that these or similar types of programs constitute technology transfer, while officials at the 10 remaining laboratories did not. In addition, DOE and laboratory officials we spoke with said that applied research programs can involve extensive knowledge- or technology-sharing activities with private industry that do not, however, take place under a CRADA or another type of agreement widely viewed as technology transfer. In response to a solicitation from the National Energy Technology Laboratory, for example, a private company was awarded DOE funding and an opportunity to work with the laboratory to develop and test a more energy-efficient method for drying the coal used in many power plants.

Nevertheless, without a clear definition, it is impossible to accurately quantify the overall extent of technology transfer at DOE's laboratories because the decision to include or exclude certain agreements and activities can materially alter any measure of technology transfer. For example, in fiscal year 2008, the 17 laboratories had nearly 7,500 work-for-others agreements in total—about 4,900 with other federal agencies and 2,600 with nonfederal entities. The total revenue from these work-for-others agreements was about $2.1 billion—$1.9 billion from work for other federal agencies and $232 million from work for nonfederal entities. Because the number of agreements and associated revenue for work for other federal agencies is a large portion of the total, whether or not this work is considered technology transfer will significantly affect any characterization of the extent of technology transfer activities at the laboratories.

DOE Cannot Determine the Effectiveness of Technology Transfer at Its Laboratories because It Has No Overarching Goals or Reliable Performance Data

DOE Has Not Established Overarching Goals for Technology Transfer

DOE cannot determine the overall effectiveness of its laboratories' technology transfer efforts because it has not yet defined its overarching strategic goals for technology transfer. The Energy Policy Act of 2005 required that DOE establish goals for technology transfer and provide Congress its plan for implementing those goals no later than February 8, 2006. As of March 2009, more than 3 years after the deadline, DOE headquarters had not yet established departmentwide goals for technology transfer or submitted its plan to Congress. DOE's efforts to develop departmentwide goals and an implementation plan began about 18 months after the deadline imposed by the act. In a June 2007 memo by the Secretary of Energy appointing the Under Secretary for Science as the department's technology transfer coordinator, the secretary directed the coordinator to establish a Technology Transfer Policy Board and made that board responsible for developing the implementation plan, including departmentwide technology transfer goals. In March 2009, members of the policy board told us that they do not currently know when the plan will reach Congress. Although a plan has been drafted, officials said that no further progress will be made until a new technology transfer coordinator is appointed and the plan can be reviewed and modified as needed to reflect the priorities of the new Secretary of Energy and other key officials.

Absent departmentwide strategic goals, some DOE programs have articulated their own goals for technology transfer. The National Nuclear

Security Administration (NNSA)—which oversees the Lawrence Livermore, Los Alamos, and Sandia national laboratories—is considering ways to expand its laboratories' technology partnerships with other federal agencies and nonfederal entities, as part of its ongoing effort to transform the nuclear weapons complex, so that it may more effectively respond to a broader range of national security threats.[19] A February 2008 white paper described strategies by NNSA's Office of Institutional and Joint Programs for increasing NNSA laboratories' outreach efforts and ability to partner with others, including steps for streamlining NNSA and laboratory business rules and processes for executing CRADAs, work-for-others agreements, and other agreements. Similarly, a goal of "effective and coordinated" commercialization of technologies was included in the planning of DOE's new bioenergy research centers, based at the Oak Ridge National Laboratory in Tennessee and the Lawrence Berkeley National Laboratory.[20] Funded by the Office of Science, the centers bring together personnel and resources from DOE laboratories, universities, private companies, and nonprofit organizations to collaborate on research and development of new and more efficient methods of transforming plant materials—potential energy crops beyond corn, such as switchgrass, poplar, and rice—into ethanol or other fuels as a substitute for gasoline. At the Oak Ridge center, the collaborating institutions created a management plan for how inventions developed through the center's research would be disclosed and revenues from technology licenses shared. To increase the likelihood that technologies will be commercialized, a council, comprising technology transfer specialists from the collaborating institutions, was formed to evaluate the commercial potential of all new inventions arising from the center's research. According to a laboratory official, since the center began operating in early 2008, the commercialization council has evaluated a number of technologies, including some that have been licensed. A similar approach is being used at the Berkeley center, although that laboratory will play a more central role in managing the intellectual property created by the center's collaborating institutions.

In addition, the contractors operating many of DOE's laboratories and the DOE program offices overseeing the laboratories have also been developing and negotiating annual performance goals for technology

[19]See GAO, *Nuclear Weapons: Views on NNSA's Proposal to Transform the Nuclear Weapons Complex*, GAO-08-1032T (Washington, D.C.: July 17, 2008).

[20]At the same time, DOE also funded a third bioenergy research center at the University of Wisconsin.

transfer, which are incorporated into the laboratories' contracts. For fiscal year 2008, contracts for 12 of the 17 laboratories included performance goals related to technology transfer—up from 10 laboratories in 2007. The goals varied widely across the laboratories, however, ranging from specific numerical targets to more process-oriented goals. For example, Lawrence Livermore National Laboratory set a target of doubling its new technology-licensing agreements from 20 to 40, from 2008 to 2012. In contrast, a fiscal year 2008 goal at Brookhaven National Laboratory in New York focused on improving administrative processes, in order to help put technology transfer agreements in place more quickly. Furthermore, laboratories' goals can change from year to year to focus on different priorities, which can make it more difficult to evaluate the laboratories' performance over time. In fiscal year 2009, for example, Oak Ridge National Laboratory set a new goal of increasing its technology transfer office's interaction with that laboratory's new technology park, which houses private companies collaborating with the laboratory's scientists.

Data Used to Measure Technology Transfer Efforts Are of Questionable Reliability

In addition to lacking departmentwide goals and an implementation strategy for technology transfer, DOE uses data of questionable reliability to evaluate its laboratories' overall effectiveness in transferring their technologies. Under the Technology Transfer Commercialization Act of 2000,[21] Congress required all federal agencies that operate or direct laboratories to prepare annual reports on the agency's technology transfer activities for the Office of Management and Budget, which are summarized in an annual report to Congress and the President. As part of this effort, DOE has been collecting data annually from its 17 laboratories on the number of technology transfer agreements—CRADAs, work-for-others agreements, technology licenses, and user-facility agreements—and dollar amounts associated with these agreements. The department also issued annual technology transfer reports on its activities for fiscal years 2001 through 2006 and continues to collect these data from its laboratories.

We found that the completeness and accuracy of DOE's technology transfer data are questionable. In some cases, laboratories failed to provide data on certain types of technology transfer agreements and DOE failed to ensure that the laboratories were reporting the data as requested. For example, 3 of the 17 laboratories did not provide complete information on their federal or nonfederal work-for-others agreements,

[21] Pub. L. No. 106-404, 114 Stat. 1742, 15 U.S.C. § 3710(f).

even though this information was requested in DOE's reporting guidelines. One laboratory failed to report complete information on its federal work-for-others agreements for fiscal years 2004 through 2008. This laboratory's officials told us that their laboratory does not consider all federal work-for-others agreements to be technology transfer, and, unlike nonfederal work-for-others agreements, federal work-for-others is not handled through the laboratory's technology transfer office. In other cases, laboratories used inconsistent reporting methods or failed to report their data accurately. Officials at one laboratory told us they excluded from their annual reporting any work-for-others agreements for which no funding was received during the year, whereas officials at another laboratory said they reported on all open agreements, regardless of whether there was funding activity. Also, as the result of our review, three laboratories made corrections to technology transfer data they had previously submitted to DOE, including data on the number of technology licenses in fiscal years 2004 through 2007, and funds associated with CRADAs and work-for-others agreements. Moreover, to help us verify the reliability of DOE's technology transfer data and obtain addition information on its laboratories' technology transfer activities, in November 2008 we collected data from the 17 laboratories on their activities during fiscal years 2006 through 2008 and found discrepancies between DOE's data and our own. For example, one laboratory had reported to DOE that it had 158 nonfederal work-for-others agreements in fiscal year 2008 but reported to us that it had 114 such agreements that year—a 39 percent difference. Likewise, there were similar discrepancies in the data reported by other laboratories, including differences as large as 55 percent in the number of nonfederal work-for-others agreements in fiscal year 2008. Overall, however, the difference in the total number of these agreements for all 17 laboratories was smaller—only 6.2 percent.

Officials from DOE's Technology Transfer Policy Board also said they recognize that the current performance measures have some limitations in providing a clear picture of the effect of technology transfer activities. They said they are currently working to develop improved measures of technology transfer performance. At least one measure—the data element capturing the number of startup companies established to commercialize the DOE laboratories' technologies—however, may go beyond simply tallying agreements and associated revenues.

Some DOE, laboratory, and non-DOE officials we interviewed said that broader results, such as the economic benefits of technology transfer, while informative, are difficult to measure, in part because tracking technologies once they have left the laboratories can be difficult. While some technology licenses provide that laboratories shall receive some information about the extent to which licensed technologies are commercialized—if licensees agree to pay royalties to the laboratory once the technologies have been integrated into commercial products and sold, for example—laboratories may not be able to assess the outcomes of other technology transfer agreements as easily. In some cases, laboratories may not be privy to the results of technology transfer agreements. For example, companies that perform research at DOE's user facilities under a proprietary user-facility agreement are not required to make public the results of their work. And, while these facility users may have to disclose to the government any patentable technologies resulting from this research, they are not required to report on the commercial success of those technologies. In other cases, the results of technology transfer agreements might never be commercialized, or it could take years before the results are used in commercial products or applications—particularly if the technology transfer agreement took place at an early stage of research and development.

Nonetheless, a few organizations within DOE are attempting to measure the economic and environmental impacts of their research, development, and technology deployment efforts, including technology transfer. For example, as part of an effort by several DOE program offices to measure the overall benefits of the department's research, development, and technology deployment programs, DOE's Office of Energy Efficiency and Renewable Energy has forecast various economic and environmental outcomes of the activities it funds at the National Renewable Energy Laboratory, other DOE laboratories, and non-DOE institutions. Specifically, in March 2007, the office estimated that as a result of these efforts, in 2010, U.S. consumers would begin saving approximately $2.1 billion to $4.3 billion[22] in annual energy costs and avoid the annual emission of up to 9 million metric tons of greenhouse gases. According to the office's estimates, these energy-cost and carbon-emissions savings could accelerate substantially over time, depending on such factors as future energy prices or public policy. Similarly, DOE's Office of Fossil Energy—which funds fossil energy research both internally, at the National Energy Technology Laboratory, and at outside institutions—estimated that its pollution-control research, development, and technology

[22]These consumer savings, as described in *Projected Benefits of Federal Energy Efficiency and Renewable Energy Programs, FY 2008 Budget Request*, March 2007 (NREL/TP-640-41347), are expressed in 2004 dollars.

deployment efforts since the 1970s are responsible for a 93 percent drop in the costs of removing nitrous oxide pollutants from power plant emissions. Although such accomplishments may depend, in part, on successfully transferring laboratory technologies, these offices' performance measures reflect the results of a broader array of programmatic activities.

Challenges Can Constrain Commercialization of DOE Laboratory Research, but Innovative Approaches Show Promise

Challenges throughout the Technology Transfer Process Can Constrain DOE Laboratories' Efforts to Identify and Transfer Technologies for Others to Commercialize

Throughout the technology transfer process—which generally includes identifying promising technologies created at DOE's laboratories, attracting potential partners to commercialize the laboratories' technologies or tap into the laboratories' capabilities, and negotiating technology transfer agreements—the laboratories face a number of challenges. Technology transfer officials at the 17 laboratories identified three main challenges that constrain the number of promising technologies transferred out of the laboratories or limit laboratories' ability to share their capabilities: competing priorities within a laboratory or a lack of staff with the expertise to identify and promote technologies having commercial promise; lack of funding to develop and demonstrate promising technologies in order to attract partners willing to commercialize them; and DOE-required terms and conditions of technology transfer agreements, which sometimes complicate negotiations with potential partners.

Competing priorities, insufficient numbers of technology transfer staff, or gaps in staff expertise have sometimes constrained laboratories' ability to recognize and promote technologies with commercial promise. DOE has acknowledged that although laboratory staff, particularly scientists, excel at innovation and invention, not all of them look beyond their research to possible applications in the marketplace. Some laboratory officials attributed this situation to a lack of interest in the processes involved in transferring technologies, while other laboratory officials said that their scientists are more focused on research and publication of their results than on collaborating with private companies. The Federal Technology Transfer Act of 1986,[23] however, makes technology transfer a responsibility of all federal laboratory scientists and engineers. Sometimes the commercial potential of certain research may not be evident until late into or after the research effort. As a result, laboratories may overlook or fail to promote promising technologies. In addition, technology transfer officials at 9 of the 17 laboratories said their laboratories may lack sufficient numbers of technology transfer staff or that skill gaps among the staff may constrain their laboratories' ability to identify and promote promising technologies. For example, technology transfer officials at one laboratory said that the number of staff devoted to technology transfer had declined from previous levels due to budget cuts, constraining the laboratory's ability to promote its technologies and identify and negotiate with potential partners. Officials at another laboratory said that while technology transfer staff have the technical expertise to understand the laboratory's technologies, the laboratory lacks sufficient staff with the entrepreneurial or business development background needed to assess the commercial potential for all their technologies and match them with market needs. As a result, potential partners may be unaware of some commercially promising technologies at the laboratory. In addition, private sector representatives who have worked with DOE laboratories said that laboratory officials sometimes do not fully understand the marketplace or commercialization process beyond the laboratory's involvement.

After DOE's federally funded research effort has ended and promising technologies have been identified, additional development or testing may be needed before the laboratory can attract entities to license and commercialize those technologies. Known as the "valley of death," the situation can result in a failure to transfer promising technologies because, on the one hand, DOE has limited funding to continue research beyond its initial mission scope and, on the other, potential industry partners are often reluctant to assume the risks of investing in technologies whose potential has not been demonstrated with a prototype, performance data, or similar evidence. Technology transfer officials at 14 of the 17 laboratories told us that the lack of funding for additional development or

[23]Pub. L. No. 99-502, § 4, 100 Stat. 1785, 1790 (1986).

testing was a significant constraint to transferring their promising technologies to the marketplace.[24] Examples of promising technologies currently languishing in the "valley of death" include the following:

- Scientists at Oak Ridge National Laboratory developed a technology that detects toxic agents in water supplies, such as reservoirs, rivers, and lakes, by analyzing the effects of such agents on algae occurring naturally in the water. Although the technology, which gives results faster than present methods for testing water safety, has been licensed, and municipalities have shown interest in it, according to laboratory officials, adoption by municipalities has been stalled by lack of funding to develop a prototype, which is needed before the Environmental Protection Agency can certify the technology for monitoring drinking water.

- Officials at Idaho National Laboratory identified 14 technologies that showed promise but had not been successfully transferred out of the laboratory, including a process for creating synthetic fuels from carbon dioxide, electricity, and steam. The same technology can also create hydrogen, which can itself be turned into electricity. Thus the technology could help in a transition away from fossil fuels. According to laboratory officials, the technology has garnered "a high degree of interest" from industry but lacks funding for further research and development, which will be needed to attract private investment.

- Similarly, a device, known as a carbon-ion pump, shows promise as a technology for removing carbon dioxide from industrial emissions. According to the technology transfer office at Lawrence Livermore National Laboratory, where the device was developed, the pump involves a simple process for removing carbon dioxide from the air and other gases, is appropriate for small industrial plants, and can produce clean water as a by-product. The director of the laboratory's technology transfer office identified the pump as 1 of 20 technologies at the laboratory that

[24]Although DOE laboratories have sometimes used CRADAs to develop and help commercialize promising technologies, the use of CRADAs peaked in the mid-1990s, when DOE, in response to congressional direction, phased out a program whose specific purpose was to provide DOE resources for CRADAs. Although DOE may use its program funding to offset the costs of DOE laboratory work performed under CRADAs, programs may be less likely to do so if the CRADA does not meet the specific goals of a particular DOE research program. For additional information, see GAO, *Technology Transfer: Several Factors Have Led to a Decline in Partnerships at DOE's Laboratories*, GAO-02-465 (Washington, D.C.: Apr. 19, 2002).

had significant potential but needed funding for additional research and development before they could increase opportunities for commercial partnerships.

Even when outside entities are interested in partnering with a laboratory, negotiating technology transfer agreements can sometimes be problematic. Although laboratory contactor officials generally negotiate the agreements with their potential partners, the agreements must be approved by DOE and include certain terms and conditions required by federal law or DOE policy. While these terms and conditions may reflect legal requirements and address legitimate policy concerns, officials at each of the 17 laboratories said that they can also present difficulties for partnering entities, sometimes slowing the negotiating process or discouraging potential partners. For example, outside entities entering into a work-for-others agreement with a DOE laboratory must agree to pay in advance, most typically, for 90 days of the work. Officials at several of the laboratories said that this requirement can be especially problematic for small businesses because they may not have enough capital to pay in advance. Also, the requirement does not reflect standard commercial practices and can therefore prolong negotiations even with businesses that can afford to fund the work up front. DOE headquarters officials representing the Technology Transfer Policy Board and the Office of the General Counsel told us, however, they are concerned that without the requirement DOE could be violating federal appropriations laws, because budgetary resources would have to be used to cover any costs that a sponsor failed to pay. Other terms and conditions require the laboratories' CRADA partners and licensees to laboratory inventions to "substantially manufacture" in the United States any commercial products that include technologies licensed from DOE laboratories.[25] Officials from several DOE laboratories and a number of private-sector representatives we interviewed said that the requirement can present difficulties, in particular for companies that typically manufacture their products overseas. According to DOE headquarters officials, the requirement reflects federal and DOE policies of supporting U.S. industrial competitiveness. Nevertheless, private-sector representatives we contacted emphasized the importance of reaching an acceptable agreement with the laboratories within a reasonable time frame, in light of competition in the marketplace.

[25] Alternatively, the licensee or CRADA partner may make a legally binding commitment to provide an "alternate net benefit to the U.S. economy."

Some DOE Laboratories and Programs Have Developed Their Own Approaches to Increase Technology Transfer

To bridge the gap between the laboratories' research focus and the need to transfer technologies beyond the laboratories, technology transfer officials have taken a number of steps, such as the following:

- At Lawrence Livermore National Laboratory, technology transfer officials regularly evaluate their laboratories' pending research publications for evidence of inventions or technologies that have not been disclosed for commercial opportunities that may have been overlooked.

- Technology transfer officials at some DOE laboratories that are managed and operated by universities—such as Ames Laboratory, which is managed by Iowa State University, and the SLAC National Accelerator Laboratory, managed by Stanford University[26]—work with the universities' technology transfer offices to help the laboratories patent technologies and manage intellectual property.

- Technology transfer officials at Brookhaven National Laboratory expanded their office's reach by working with their laboratory's public relations office to promote selected technologies, which proved successful in attracting licensees for those technologies.

- Four laboratories have brought in entrepreneurs-in-residence, representing venture capital firms, with strong backgrounds in business and science to help identify and commercialize promising technologies. DOE's Office of Energy Efficiency and Renewable Energy funded entrepreneurs at three of these laboratories—the National Renewable Energy Laboratory and Oak Ridge and Sandia national laboratories.[27] These entrepreneurs had 1 year to identify at least one energy-efficiency or renewable-energy technology and develop a plan for commercializing it. The Sandia-based entrepreneur told us that, after months of reviewing the laboratory's technologies, he estimated that 80 percent of the more than 100 technologies he assessed were promising and could be ready for commercialization in about 1 year, after additional development or testing. DOE plans to fund entrepreneurs at four additional laboratories in 2009.

To reduce the number of technologies stalled in the "valley of death," a DOE program office and the laboratories have sought ways to fill the funding gap:

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[26]In 2008, the Stanford University-managed and operated laboratory changed its name from Stanford Linear Accelerator Center to SLAC National Accelerator Laboratory.

[27]Los Alamos National Laboratory also funded an entrepreneur there from 2005 to 2008.

- The Office of Energy Efficiency and Renewable Energy in 2007 and 2008 awarded over $14 million to eight DOE laboratories to help those laboratories fund additional research and development on their promising clean-energy technologies. For example, the National Renewable Energy Laboratory used $250,000 of grant money for additional research on advanced cooling fan technology, which came out of the laboratory's geothermal energy research from the 1990s, that could also be used to cool industrial plants more efficiently than current technologies. An industrial partner approached the laboratory willing to match the laboratory's $250,000 investment, as required by the grant program, and then commercialize the technology. According to laboratory officials, the laboratory used the money and industry partner matching funds to develop a prototype of the technology for the industrial setting, which the partner is currently commercializing and expects to bring to market in 2009.

- Officials at several laboratories said they invest a portion of the laboratories' licensing income in other technologies in need of further research and development to help make them more attractive to outside investors. For example, technology transfer officials at the Idaho National Laboratory said this laboratory invests approximately $300,000 to $400,000 of its annual licensing income for this purpose. An internal committee reviews the laboratory's technologies and selects those to be developed and, it is anticipated, eventually licensed and commercialized. In one case, the laboratory spent licensing income to develop a method of producing nanotechnologies that are useful in solar energy and other applications, which attracted a startup company interested in commercialization. According to laboratory officials, such investments have been highly successful, not only for bridging the "valley of death," but also for generating new funding to develop the technology and licensing income for the laboratory.

Finally, the laboratories have taken steps to simplify the negotiation of technology transfer agreements:[28]

[28]One laboratory, the Pacific Northwest National Laboratory, has a unique arrangement, called a "use permit," which allows the nonprofit research organization contracted to operate the laboratory to use the laboratory facilities and staff for its own research and technology-sharing activities. This arrangement also provides the contractor enhanced flexibility to negotiate agreements with potential partners for activities falling under its use permit. The use permit will end in 2012. See appendix III for more information.

- Some laboratories have worked with local DOE officials to develop standard technology transfer agreements with terms and conditions that DOE has preapproved, allowing the laboratories to avoid seeking DOE approval for agreements being negotiated with potential partners. Officials at Brookhaven National Laboratory told us that, as a result of using preapproved agreements, they have been able to reduce the time it takes to put technology transfer agreements in place—down to 1 day in some cases.

- At least one laboratory has taken this approach a step further by creating standardized agreements that apply to specific entities with which the laboratories expect to have a longer-term partnership. Savannah River National Laboratory in South Carolina, for example, has developed a "model" CRADA for its cooperative research projects with universities in South Carolina.

- Similarly, Sandia and Los Alamos national laboratories have set up "umbrella" CRADAs with major companies, such as Goodyear or Chevron, with which the laboratories have ongoing partnerships and enter into multiple agreements. Under these agreements, the laboratories and their partners have agreed in advance to certain terms and conditions, such as the parties' rights to review one another's draft publications or their rights of ownership of intellectual property resulting from the cooperative research. Other terms and conditions, such as the scope of work to be completed, are negotiated when new work is being considered by the parties. Officials at one of these laboratories told us that standardizing agreements has streamlined the negotiating process and resulted in more long-term partnerships with industry.

- In addition, laboratories have taken other steps to mitigate sometimes problematic terms and conditions of technology transfer agreements. The contractor operating Lawrence Berkeley National Laboratory, for example, sometimes uses its own funds to help potential partners pay in advance for 90-days' work toward their technology transfer agreement.

At headquarters, DOE officials have also taken some steps to increase the likelihood that promising technologies will be transferred out of the laboratories and commercialized. The Technology Transfer Policy Board has published in the Federal Register a request for information from private industry, DOE laboratories, and others seeking to identify problems with DOE's current technology transfer agreements, along with best practices DOE could consider. As of April 2009, DOE was consolidating responses to its request. The board has also altered some user-facility agreements to make it easier for users to collaborate with laboratory staff.

Approaches Used Outside DOE Could Offer Additional Ways for Strengthening DOE's Own Efforts

Other federal laboratories outside DOE are using other approaches aimed at increasing technology transfer. To learn about some of these approaches, we spoke with Department of Defense (Defense) officials from the Office of Technology Transition—created to oversee and encourage technology transfer departmentwide—as well as officials who more directly oversee technology transfer for the Office of Naval Research and the Army and Air Force research laboratories. According to these officials, certain efforts by the Office of Technology Transition have helped technology transfer staff at Defense's laboratories enhance their capabilities, resulting in additional technology transfer opportunities. Specifically:

- **Training and networking opportunities:** The Office of Technology Transition sponsors annual departmentwide training and networking sessions for technology transfer staff, which sometimes include private industry representatives interested in partnering with Defense laboratories. Training topics range from general overview of technology transfer, aimed at new technology transfer staff, to more specific topics, such as negotiation techniques or legal issues. The officials we spoke with said that these sessions are well received and represent a valuable training opportunity and a means for sharing best practices.

- **Web-based information sharing:** The Office of Technology Transition also funds a searchable Web-based tool that enables all of the Defense laboratories to publicize in a single location their available technologies and partnering opportunities to potential partners within and outside the government. The site helps consolidate and organize information on licensing and partnering opportunities available at approximately 120 Defense laboratories and programs.

- **Funding for additional expertise at Defense laboratories:** The Office of Technology Transition pays for contracts with outside experts, used as needed by Defense's laboratories to supplement their technology transfer staff members' capabilities.[29] According to the Defense officials we spoke

[29]Defense's Office of Technology Transition contracts with these experts under authority provided in 15 U.S.C. § 3715, "Use of Partnership Intermediaries," according to an official in that office.

with, the laboratories have used these experts to help identify promising technologies, publicize technology partnering opportunities, identify potential partners, or assist in negotiating technology transfer agreements. Defense officials said the contracted experts have helped technology transfer offices with small numbers of staff carry out additional technology transfer activities. Laboratories have also benefited from some of the experts' connections with industry, as well as from their business development experience.

Although DOE and its laboratories have taken various steps to improve technology transfer, approaches used by Defense or suggested by others outside DOE could offer additional strategies for DOE to strengthen its own technology transfer efforts. Specifically, although DOE laboratory technology transfer staff may share best practices through the Technology Transfer Working Group or less formal means, DOE does not organize regular departmentwide training or networking opportunities for all DOE and laboratory staff involved in technology transfer. According to the department, only DOE and laboratory attorneys involved in intellectual property issues and technology transfer meet annually for networking and training. Likewise, while several of the laboratories showcase their technology transfer opportunities on their public Web sites, DOE does not have a departmentwide database, consolidating this information in a single location, and interested parties would have to compile information from multiple Web sites to obtain a more complete view of DOE's technology transfer opportunities.[30] Lastly, although outside experts—such as the entrepreneurs funded by DOE's Office of Energy Efficiency and Renewable Energy—have been made available at a few of DOE's laboratories, to date not all of the laboratories have benefited. In contrast, the outside experts under contract with the Department of Defense's Office of Technology Transition are available to all of the laboratories to carry out a wider variety of tasks than the entrepreneurs funded by DOE and are not focused on commercializing a single technology. Furthermore, unlike the entrepreneurs, who are available to the participating

[30]DOE, in fact, has a single searchable Web site showcasing current opportunities to license DOE laboratory technologies, but only technologies owned by DOE; the site does not include laboratory technologies owned and patented by the contractors operating most of the 17 laboratories. If DOE laboratory contractors do not elect title to inventions made at the laboratory within a certain time frame, DOE may decide to pursue patents (or other legal protection for intellectual property) and then license the patented technologies to interested parties. According to DOE's Office of the General Counsel, because DOE only owns 5 to 10 percent of the new inventions made at the laboratories, the Web site only includes a fraction of the technologies at the laboratories.

laboratories for a limited duration, the Department of Defense's experts are available on an ongoing basis. In addition, private industry representatives, including those responding to DOE's request in the Federal Register, offered suggestions for improving DOE's technology transfer, such as a venture capital firm's suggestion that DOE ensure adequate resources are available departmentwide for developing or testing promising technologies to attract industry.

Conclusions

DOE's national laboratories and specialized research facilities, long a source for groundbreaking research and technical innovation, routinely share their technologies and unique capabilities with others, helping pave the way for technological solutions and economic opportunities in diverse fields ranging from solar energy to health care. The unprecedented scale and urgency of the challenges currently threatening the economy, natural environment, and global security clearly signal the need for new technologies and effective collaborations among those capable of developing and commercializing them. While DOE has made invaluable contributions in this regard, more could be done to ensure that promising technologies are being transferred. Unclear priorities within DOE about the role of technology transfer are complicating the already difficult task of transferring and commercializing new technologies. DOE's lack of overarching goals—including a consensus on what activities constitute technology transfer—and reliable performance data have left DOE's laboratories and program offices to chart their own course, often with mixed results. While some laboratories have used various approaches to help address the constraints that limit their technology transfer efforts, not all the laboratories or programs have done so. Other strategies, such as those employed by the Department of Defense, could further enhance the laboratories' capacity to transfer their technologies and speed the arrival of solutions to the commercial marketplace. Given the billions spent each year on research at DOE's laboratories and the urgency of today's challenges, DOE needs to take a stronger role in ensuring that its laboratories are providing the maximum return on the public's investment in federal research.

Recommendations for Executive Action

To better measure, and improve, the effectiveness of DOE's technology transfer efforts, we recommend that the Secretary of Energy, working in concert with laboratory directors, take the following seven actions:

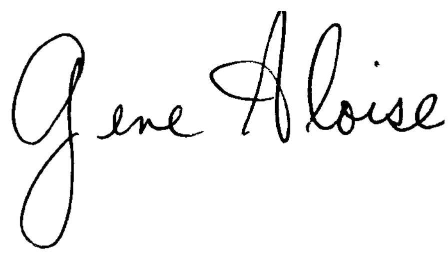
- explicitly articulate departmentwide priorities for DOE's technology transfer efforts;
- develop clear goals, objectives, and performance measures in line with these priorities;
- clarify which activities qualify as technology transfer, including whether research sponsored by other federal agencies qualifies;
- collect reliable performance data and further consider ways to use the data to monitor the progress and effectiveness of technology transfer efforts;
- ensure sufficient laboratory access to both technical and business development expertise;
- develop a systematic approach to identify technologies with commercial promise; and
- develop a comprehensive means of sharing information across laboratories and with private entities, such as a Web-based clearinghouse for technologies ready for further development or commercialization.

Agency Comments and Our Evaluation

We provided a draft of this report to the Secretary of Energy for review and comment. The Acting Director of the Office of Science responded on behalf of DOE and generally agreed with our findings. Although DOE was silent on whether it agreed or disagreed with our recommendations, DOE noted that many of the recommendations touch upon policy issues that will likely be addressed under the new administration. DOE's written comments on our draft report are included in appendix IV. DOE also provided technical comments that we incorporated as appropriate.

We are sending copies of this report to interested congressional committees, the Secretary of Energy, and other interested parties. In addition, this report will be available at no charge on the GAO Web site at http://www.gao.gov.

If you or your staffs have any questions about this report, please contact me at (202) 512-3841 or aloisee@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are listed in appendix V.



Gene Aloise
Director, Natural Resources and Environment

Appendix I: Scope and Methodology

To determine the nature and extent of technology transfer at the Department of Energy's (DOE) laboratories, we reviewed the federal laws and DOE policies and guidance related to technology transfer. We also analyzed technology transfer data collected annually by DOE headquarters from the department's national laboratories and other facilities, which are responsible for carrying out DOE's technology transfer. We contacted the officials responsible for technology transfer at DOE's 17 national laboratories:

- Ames Laboratory, Iowa;
- Argonne National Laboratory, Illinois;
- Brookhaven National Laboratory, New York;
- Fermi National Accelerator Laboratory, Illinois;
- Idaho National Laboratory, Idaho;
- Lawrence Berkeley National Laboratory, California;
- Lawrence Livermore National Laboratory, California;
- Los Alamos National Laboratory, New Mexico;
- National Energy Technology Laboratory, Oregon, Pennsylvania, and West Virginia;
- National Renewable Energy Laboratory, Colorado;
- Oak Ridge National Laboratory, Tennessee;
- Pacific Northwest National Laboratory, Washington;
- Princeton Plasma Physics Laboratory, New Jersey;
- Sandia National Laboratories, California and New Mexico;
- Savannah River National Laboratory, South Carolina;

- SLAC National Accelerator Laboratory, California;[1] and
- Thomas Jefferson National Accelerator Facility, Virginia.

According to DOE's data, the 17 national laboratories were responsible for more than 92 percent of the cooperative research and development, work for others, and technology licensing agreements during fiscal years 2006 and 2007. We interviewed contractor officials responsible for technology transfer at each of these laboratories—including visits to the Lawrence Livermore, Lawrence Berkeley, and Pacific Northwest national laboratories—about the nature and extent of their technology transfer efforts. We also discussed at most laboratories the officials' efforts to ensure the accuracy or completeness of technology transfer data collected annually by DOE headquarters. Although we determined that DOE's data were sufficiently reliable for selecting the laboratories to contact during this study or reporting the total number of agreements at DOE laboratories, we were unsure about whether they could be used to report on the precise extent of technology transfer at individual laboratories. As a result, in November 2008, we collected additional data from the 17 laboratories about their technology transfer agreements in fiscal years 2006 through 2008, including selected information about the number of these laboratories' cooperative research and development, work for others, patent licensing, and user-facility agreements and revenues associated with these agreements. Because there were indications in the DOE data that its laboratories were using inconsistent methods for reporting the dollars associated with some of its agreements—work-for-others agreements, in particular—and DOE could not verify the reliability of its data, we asked the 17 laboratories to report this data using a consistent definition.[2] Also, to reduce respondent burden, we limited the data we collected on the number of the laboratories' licensing agreements to focus exclusively on patented technologies licensed to private industry. And, we limited the data we collected on revenues from user-facility agreements to focus on agreements with private industry because, according to DOE officials, most such revenues come from proprietary user-facility agreements with private industry. In addition, we collected data and other information about "use permit" agreements, which are

[1]In 2008, the Stanford University-managed and operated laboratory changed its name from Stanford Linear Accelerator Center to SLAC National Accelerator Laboratory.

[2]Specifically, we asked the laboratories to report on the dollars "costed"—or actual costs—of the work performed under these agreements in the fiscal year.

unique to 1 of the 17 laboratories. (See app. II for data on the 17 laboratories' agreements and app. III for information on "use permit" agreements.) Furthermore, we spoke with DOE headquarters officials from the Office of the General Counsel, the Office of Laboratory Policy and Evaluation in the Office of Science, and the Technology Transfer Policy Board. We also spoke with members of DOE's Technology Transfer Working Group.

To determine the extent to which DOE can measure the effectiveness of technology transfer efforts at its laboratories, we obtained and analyzed the laboratories' annual performance goals and assessments for fiscal years 2006 through 2009, as available, as well as documentation of DOE program-office efforts to establish technology transfer goals. We also discussed performance measurement issues with the 17 laboratories and DOE headquarters officials, and, to learn more about technology transfer and performance measurement from the nonfederal perspective, we spoke with associations representing university and private-sector technology managers engaged in technology transfer.

To identify the factors affecting technology transfer and approaches that may have potential for improving technology transfer, we asked the technology transfer officials at the 17 laboratories and DOE headquarters officials to discuss key factors, positive or negative, affecting DOE's ability to transfer its technologies, as well as any efforts to improve technology transfer or helpful practices. As appropriate, we obtained documentation of factors that were mentioned and results of any improvement efforts. Finally, to better understand how other federal agencies transfer technology, we interviewed Department of Defense officials who oversee technology transfer in that department's Office of Technology Transition, Army and Air Force Research Laboratories, and the Office of Naval Research about the strategies used to transfer technologies.

We conducted this work as a performance audit from July 2008 through June 2009, in accordance with general accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Appendix II: Information on the Department of Energy's Technology Transfer Agreements and Associated Revenue

DOE's laboratories share their technologies, capabilities, and knowledge with other entities through a variety of activities. Certain activities, and the agreements used to implement them, are widely regarded as technology transfer. The four primary types of technology transfer agreements are cooperative research and development, work for others, licensing, and user-facility agreements. The following tables contain information about the type and number of these agreements for fiscal years 2006 through 2008 and, when available, the associated revenue at the 17 DOE laboratories we reviewed.

Cooperative Research and Development Agreements

Under a cooperative research and development agreement (CRADA), laboratory employees collaborate with nonfederal partners to carry out research that will benefit DOE program missions and the partners' research and development goals. As shown in table 1, the majority of CRADAs are with private partners, defined as for-profit firms (domestic or foreign), industry associations, or consortia whose members include representatives from private industry. A few of the laboratories, including Los Alamos National Laboratory and the National Renewable Energy Laboratory, often partner with other entities such as universities or state and local governments.

Table 1: Number of Cooperative Research and Development Agreements, Fiscal Years 2006 through 2008

	All CRADAs			CRADAs with private partners[a]		
DOE national laboratory or facility	**2006**	**2007**	**2008**	**2006**	**2007**	**2008**
Ames	3	3	5	3	3	5
Argonne	37	42	32	37	42	32
Brookhaven	50	54	47	50	54	47
Fermi Accelerator	3	6	10	3	6	10
Idaho	64	76	67	57	68	61
Lawrence Berkeley	13	14	12	13	14	12
Lawrence Livermore	33	38	36	33	38	36
Los Alamos	55	70	89	48	61	70
National Energy Technology	38	33	28	31	26	21
National Renewable Energy	49	52	94	37	40	72
Oak Ridge	78	88	65	76	87	62
Pacific Northwest[b]	30	43	38	30	43	38
Princeton Plasma Physics	0	1	1	0	1	1
Sandia	139	149	138	139	148	137
Savannah River	8	10	11	4	5	6

DOE national laboratory or facility	All CRADAs 2006	All CRADAs 2007	All CRADAs 2008	CRADAs with private partners[a] 2006	CRADAs with private partners[a] 2007	CRADAs with private partners[a] 2008
SLAC Accelerator	5	11	11	5	11	11
Thomas Jefferson Accelerator	6	6	5	6	6	5
Total	**611**	**695**	**689**	**572**	**653**	**626**

Source: GAO analysis of national laboratories' data.

[a]CRADAs with private partners are a subset of all CRADAs.

[b]Figures for the Pacific Northwest National Laboratory do not include work performed under this laboratory's unique arrangement, or use permit, with DOE; see appendix III for more information.

Under a CRADA, even if laboratories contribute personnel, equipment, or other in-kind resources to a project, their CRADA partners must contribute funds (see table 2), in-kind resources, or both.

Table 2: Partner-Contributed Funds for Research under CRADAs, Fiscal Years 2006 through 2008

DOE national laboratory or facility	From all partners (dollars in thousands) 2006	From all partners (dollars in thousands) 2007	From all partners (dollars in thousands) 2008	From private partners[a] (dollars in thousands) 2008
Ames	$90	$20	$150	$150
Argonne	215	600	236	236
Brookhaven	2,000	2,100	3,700	3,700
Fermi Accelerator	44	279	445	445
Idaho	4,316	2,941	5,910	4,399
Lawrence Berkeley	600	100	500	500
Lawrence Livermore	1,240	4,142	9,972	9,972
Los Alamos	2,700	10,700	12,500	11,400
National Energy Technology	376	608	92	84
National Renewable Energy	1,776	2,179	3,102	3,102
Oak Ridge	8,300	16,300	12,400	11,200
Pacific Northwest[b]	100	100	1,400	1,400
Princeton Plasma Physics	0	0	0	0
Sandia	23,962	21,326	20,631	20,631
Savannah River	868	664	1,372	1,332
SLAC Accelerator	144	186	319	319
Thomas Jefferson Accelerator	709	600	524	524
Total	**$47,439**	**$62,844**	**$73,252**	**$69,393**

Source: GAO analysis of national laboratories' data.

Note: Because a CRADA can span multiple years, the figures in table 2 represent the amounts "costed" by the laboratories in each of the fiscal years.

[a]We collected data on funds from private partners only for fiscal year 2008; the amounts are a subset of funds from all partners.

[b]Figures for the Pacific Northwest National Laboratory do not include work performed under this laboratory's unique arrangement, or use permit, with DOE; see appendix III.

Work-for-Others Agreements

Under a work-for-others agreement, a DOE laboratory agrees to conduct research, for a fee, on behalf of a sponsor. Although this research must be consistent with the laboratory's mission and draw on the laboratory's unique capabilities, the research is not required to benefit DOE programs, as it is under a CRADA. DOE has work-for-others agreements with both federal and nonfederal entities, but DOE headquarters and its laboratories do not all agree on whether work-for-others agreements with federal entities should be considered technology transfer. Table 3 shows the relative number of work-for-others agreements carried out with federal entities; with all nonfederal entities, including private partners; and with private partners, defined as for-profit firms (domestic or foreign), industry associations, or consortia whose members include representatives from private industry.

Table 3: Number of Work-for-Others Agreements, Fiscal Years 2006 through 2008

DOE national laboratory or facility	With federal agencies			With all nonfederal entities			With private partners[a]		
	2006	2007	2008	2006	2007	2008	2006	2007	2008
Ames	11	9	10	9	10	11	7	9	8
Argonne	135	147	137	133	145	114	86	82	63
Brookhaven	122	120	107	54	55	44	16	18	14
Fermi Accelerator	4	4	3	6	3	4	4	2	2
Idaho	436	464	502	184	233	278	147	173	216
Lawrence Berkeley	294	266	244	452	431	438	157	153	158
Lawrence Livermore	598	683	711	315	335	519	314	296	277
Los Alamos	684	812	1,006	154	162	185	75	73	87
National Energy Technology	8	13	7	15	21	9	14	20	8
National Renewable Energy	63	70	79	93	110	120	90	95	106
Oak Ridge	937	1,013	1,048	447	473	556	394	421	503
Pacific Northwest[b]	462	494	491	12	20	18	2	9	7
Princeton Plasma Physics	17	17	18	8	8	8	4	3	4
Sandia	527	528	530	275	265	262	216	203	201
Savannah River	85	82	81	19	26	31	16	21	26
SLAC Accelerator	0	0	0	1	1	4	1	1	4
Thomas Jefferson Accelerator	11	10	4	9	9	10	9	9	10
Total	**4,394**	**4,732**	**4,978**	**2,186**	**2,307**	**2,611**	**1,552**	**1,588**	**1,694**

Source: GAO analysis of national laboratories' data.

[a]Work-for-others agreements with private partners are a subset of work-for-others agreements with nonfederal entities.

[b]Figures for the Pacific Northwest National Laboratory do not include work performed under this laboratory's unique arrangement, or use permit, with DOE; see appendix III.

Under a work-for-others agreement, the sponsor must pay the entire cost of a project. Table 4 shows the funds associated with work-for-others agreements from fiscal year 2006 through 2008.

Table 4: Sponsor-Contributed Funds for Research under Work-for-Others Agreements, Fiscal Years 2006 through 2008

	From federal agencies (dollars in thousands)			From all nonfederal entities (dollars in thousands)			From private partners[a] (dollars in thousands)
DOE national laboratory or facility	**2006**	**2007**	**2008**	**2006**	**2007**	**2008**	**2008**
Ames	$1,490	$1,510	$1,850	$460	$430	$850	$500
Argonne	80,400	73,800	85,700	28,300	33,000	26,889	9,400
Brookhaven	40,300	39,100	41,700	16,800	3,500	4,400	2,100
Fermi Accelerator	153	66	132	301	298	3,889	3
Idaho	165,978	192,597	256,223	12,869	12,358	8,495	4,448
Lawrence Berkeley	69,400	67,300	64,200	47,000	43,200	40,700	12,300
Lawrence Livermore	277,000	215,800	236,000	34,200	33,900	43,600	27,200
Los Alamos	232,000	216,000	207,000	16,400	15,700	21,200	8,000
National Energy Technology	527	120	833	133	37	94	94
National Renewable Energy	3,758	3,426	4,126	7,220	6,898	9,780	9,363
Oak Ridge	196,000	237,000	289,000	39,000	54,000	48,000	44,100
Pacific Northwest[b]	237,500	218,900	228,700	2,600	1,300	1,200	700
Princeton Plasma Physics	1,200	1,100	900	500	400	100	100
Sandia	380,531	390,907	430,056	28,299	24,158	20,617	17,489
Savannah River	8,764	13,414	17,801	1,177	1,396	1,931	1,791
SLAC Accelerator	0	0	0	0.5	0	0.7	0.7
Thomas Jefferson Accelerator	14,526	7,761	1,800	353	455	243	243
Total	**$1,709,526**	**$1,678,802**	**$1,866,022**	**$235,612**	**$231,029**	**$231,988**	**$137,831**

Source: GAO analysis of national laboratories' data.

Note: Because work-for-others agreements can span multiple years, the figures in table 4 represent the amounts "costed" by the laboratories in each of the fiscal years.

[a]We collected data on funds from private partners only for fiscal year 2008; the amounts are a subset of dollars from all nonfederal entities.

[b]Figures for the Pacific Northwest National Laboratory do not include work performed under this laboratory's unique arrangement, or use permit, with DOE; see appendix III.

Patent Licensing Agreements

In addition to performing research, laboratories share their technologies by licensing their patented discoveries, copyrighted software programs, or other intellectual property to nonfederal entities seeking to use or commercialize those technologies. In some cases, the licensee agrees to pay fees or royalties to the laboratory in exchange for the laboratory's permission to use or commercialize the technologies. Table 5 shows the total number of licenses with private partners. DOE may also have licensing agreements with other nonfederal entities, such as universities, which are not captured in the table.

Table 5: Number of Patent License Agreements with Private Partners, Fiscal Years 2006 through 2008, and Associated Revenue, Fiscal Year 2008

	Number of licenses			Revenue[a] (dollars in thousands)
DOE national laboratory or facility	**2006**	**2007**	**2008**	**2008**
Ames	47	45	41	$6,500
Argonne	75	89	88	3,877
Brookhaven	520	473	498	9,500
Fermi Accelerator	0	0	0	0
Idaho	70	74	79	93
Lawrence Berkeley	72	80	86	2,700
Lawrence Livermore	91	99	108	9,411
Los Alamos	148	169	187	1,500
National Energy Technology	8	10	11	67
National Renewable Energy	44	53	50	643
Oak Ridge	109	99	82	2,600
Pacific Northwest	87	81	77	3,338
Princeton Plasma Physics	2	2	3	30
Sandia	178	151	164	3,506
Savannah River	12	17	18	44
SLAC Accelerator	2	1	1	5
Thomas Jefferson Accelerator	10	10	11	40
Total	**1,475**	**1,453**	**1,504**	**$43,855**

Source: GAO analysis of national laboratories' data.

[a]We collected data on revenue from licenses to private partners for fiscal year 2008 only.

User-Facility Agreements

Under a user-facility agreement, scientists from outside organizations can use DOE's scientific equipment for their own research, sometimes in collaboration with laboratory staff. Users may conduct their research at DOE's facilities for free or a negotiated cost, if the results of their research will be made public. The users who wish to keep their results private, however, must reimburse DOE for the full cost of using the facilities. Table 6 shows the number of user facility agreements with private partners from fiscal year 2006 through 2008, and the amount paid by the partner for fiscal year 2008.

Table 6: Number of User-Facility Agreements with Private Partners, Fiscal Years 2006 through 2008, and Associated Revenue, Fiscal Year 2008

	Total agreements			Revenue[a] (dollars in thousands)
DOE national laboratory or facility	**2006**	**2007**	**2008**	**2008**
Ames	0	0	0	0
Argonne	189	202	221	$2,200
Brookhaven	85	111	163	1,000
Fermi Accelerator	0	0	0	0
Idaho	0	0	0	0
Lawrence Berkeley	82	96	119	1,700
Lawrence Livermore	0	0	0	0
Los Alamos	33	36	36	500
National Energy Technology	0	0	0	0
National Renewable Energy	0	0	0	0
Oak Ridge	75	180	157	600
Pacific Northwest	9	9	5	0
Princeton Plasma Physics	0	0	0	0
Sandia	5	6	7	69
Savannah River	0	0	0	0
SLAC Accelerator	75	75	75	376
Thomas Jefferson Accelerator	0	0	0	0
Total	**553**	**715**	**783**	**$6,445**

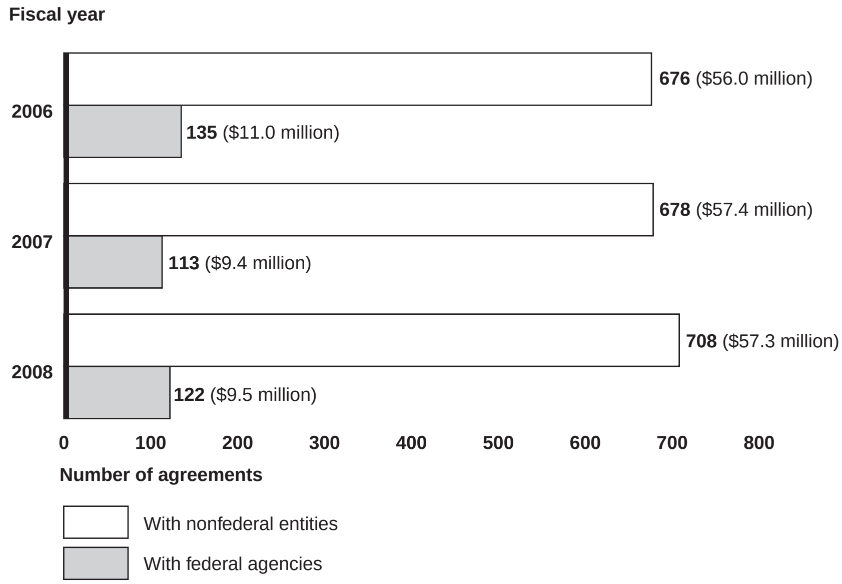
Source: GAO analysis of national laboratories' data.

[a]We collected data on revenue from user-facility agreements with private partners for fiscal year 2008 only.

Appendix III: The Use Permit at the Pacific Northwest National Laboratory

Since 1964, the contractor in charge of managing and operating the Pacific Northwest National Laboratory in southeastern Washington state has been allowed to use the laboratory's personnel and DOE-owned facilities for its own private work, subject to some restrictions, under a unique arrangement called a use permit. Due to expire in 2012, this arrangement was originally developed to stimulate economic diversity and private investment in the local community by encouraging the contractor (Battelle Memorial Institute) to pursue private research and development work and to invest in facilities and equipment at the laboratory beyond what the federal government would invest, in part to support this private research work. Pacific Northwest National Laboratory contractor officials who administer the use permit estimated that about $70 million in research and development work is performed each year under the use permit—equivalent to about 10 percent of all the work done at the laboratory. Most of this work is undertaken on behalf of outside entities—including federal agencies, private companies, universities, state or local governments, or others—that enter into agreements with the Pacific Northwest laboratory's contractor for work under the use permit. In conducting this work, however, the contractor must use its own funds to pay the full costs of using the laboratory's government-owned facilities, equipment, and personnel at the laboratory. Since fiscal year 2006, the contractor has entered into about 700 to 800 separate agreements each year under the use permit (with the same entity in some cases), the majority with nonfederal entities (see fig. 1). Laboratory contractor officials said that, because of the use permit, the laboratory does not have as many CRADAs or nonfederal work-for-others agreements as other DOE laboratories. In fiscal year 2008, for example, the Pacific Northwest National Laboratory reported having 18 nonfederal work-for-others agreements, whereas other DOE laboratories with roughly comparable budgets had, in some cases, significantly more nonfederal work-for-others agreements that year.

Figure 3: Agreements under the Use Permit at Pacific Northwest National Laboratory, Fiscal Years 2006 through 2008, and Associated Revenue



Source: GAO analysis of data from Battelle Memorial Institute.

According to contractor officials, the flexibilities afforded the contractor under the use permit—flexibilities not available at other DOE laboratories—have helped increase the extent to which the laboratory's technologies and capabilities are transferred. For example, under the use permit, the Pacific Northwest laboratory contractor may respond to competitive solicitations, such as those put out by federal agencies, and compete against private entities for research and development work to be carried out using the laboratory's facilities and staff. The contractor also has enhanced flexibility to negotiate the terms and conditions of its research agreements, enabling the parties to tailor the terms of the agreements to fit the parties' interests and making optional many of the constraints imposed by terms and conditions required under DOE's technology transfer agreements. According to laboratory contractor officials, this feature has made the use permit an attractive option for entities doing business with the laboratory and has helped bring resources into the local community, in line with the use permit's original goals. Whereas terms and conditions of DOE agreements may conflict with standard commercial practice, under the use permit the contractor can, for example, assume the risk of guarantee that it will perform the agreed-upon scope of work within the allotted budget and time frame. And, according to contractor officials, because the contractor has more flexibility to set the price of agreements, the contractor can earn a profit from work performed under the use permit, reflecting in part the risks the laboratory contractor assumes in performing work on its own account.

DOE, in contrast, has expressed concerns about the use permit arrangement. Specifically, officials in DOE's Office of Science, which oversees the Pacific Northwest National Laboratory, and Office of the General Counsel stated that the structure of the use permit limits the extent to which DOE can perform oversight. For example, work under the use permit is not allowed to interfere with research performed for DOE at the laboratory. A DOE official told us that, while he was not aware of any instances in which use permit work interfered with DOE work, DOE has limited ability to ensure this rule was followed. Furthermore, DOE officials said the flexibilities under the use permit afforded the Pacific Northwest laboratory contractor some "unfair" advantages. In responding to competitive solicitations, for example, the contractor is able to bring work into the laboratory that would otherwise be off-limits, because DOE laboratories are restricted by federal statutes, regulations, and DOE policies from directly competing for work against private entities. Likewise, competing against these private entities for work could place the entities at a distinct disadvantage, because the Pacific Northwest laboratory contractor is able to access and use publicly-funded facilities and equipment, even though the laboratory contractor is paying the full costs of using government resources. Finally, according to DOE officials, this arrangement posed problems for DOE when it attempted to recompete the contract to manage the laboratory, which was due to expire at the end of 2008. Specifically, because some work carried out under the use permit would have remained unfinished at the time a new contract was to begin, it was unclear how the current contractor would complete the work if another entity won the contract to manage the laboratory. Following negotiations on these issues in 2008, DOE and the laboratory contractor agreed to extend the management and operating contract—including the use permit—until September 2012, by which time the contractor must have concluded all of the work under the use permit. After September 2012, the use permit will be ended. DOE officials have said that in the interim, they will examine ways to enhance technology transfer departmentwide.

Although we analyzed over 300 agreements under the use permit, we were unable to determine whether those agreements ultimately led to additional technology transfer. In general, these agreements appeared to draw on the Pacific Northwest laboratory's unique capabilities—a factor considered by DOE officials to help them evaluate proposed work-for-others agreements and ensure that an agreement would not inadvertently place the laboratory into competition with the private sector—and they entailed work contributing to critical areas ranging from climate-change research to advanced homeland security technologies. Nevertheless, it was unclear to what extent these agreements would constitute technology transfer. For example, according to DOE and the contractor, a large portion of the 300 agreements could have been performed under a nonfederal work-for-others agreement, because they satisfied key criteria for performing work under those agreements. It is unknown, however, whether the partnering entities would have chosen to carry out the work, except under the use permit. As another example, agreements resulting from competitive solicitations—approximately one-third of the 300 agreements—may not have come to the laboratory without the use permit. Since traditional technology transfer agreements preclude a laboratory from competing for work, however, it is unclear whether those competitively awarded contracts for research actually constitute technology transfer.

Appendix IV: Comments from the Department of Energy

Department of Energy
Washington, DC 20585

May 29, 2009

Mr. Gene Aloise
Director, Natural Resources and Environment
U.S. Government Accountability Office
441 G Street, NW
Washington, DC 20584

Dear Mr. Aloise:

Thank you for the opportunity to comment on the draft Government Accountability Office (GAO) report, entitled *"TECHNOLOGY TRANSFER: Clearer Priorities and Greater Use of Innovative Approaches Could Increase the Effectiveness of Technology Transfer at Department of Energy Laboratories (GAO-09-548)"*. The Department of Energy agrees with many of the findings in this report. The DOE Technology Transfer Policy Board is already taking steps to examine ways to improve technology transfer activities within the Department.

Many of the recommendations made by the GAO, as well as those resulting from a study of recommendations gathered through DOE's Request for Information published November 26, 2008, *"Questions About DOE Laboratory Technology Transfer Seeking Input From All Parties Including Industry, Universities, Non-Profits and the General Public"*, which had a final deadline of March 26, 2009, touch upon policy issues that we anticipate will be addressed under the new administration.

Please find an attachment to this letter which provides additional general and specific comments on the draft report. Many of these comments were provided to the GAO in response to their initial Statement of Facts but may not have been reflected in the draft report.

Sincerely,

Patricia M. Dehmer
Acting Director
Office of Science

Appendix V: GAO Contact and Staff Acknowledgments

GAO Contact

Gene Aloise (202) 512-3841 or aloisee@gao.gov

Staff Acknowledgments

In addition to the individual named above, Janet Frisch, Assistant Director; Nabajyoti Barkakati; Ellen W. Chu; Stanley Kostyla; Jeff Larson; Omari Norman; and Jeff Rueckhaus made important contributions to this report.

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