Report
on
Technology Transfer and Related Technology Partnering Activities
at the
National Laboratories and Other Facilities

Fiscal Year 2006

Prepared by:

Office of Policy and International Affairs
U.S. Department of Energy

In Coordination With:

National Laboratory Technology Partnerships Working Group
Department of Energy Technology Transfer Working Group

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FOREWORD

On behalf of the U.S. Department of Energy (DOE), I am pleased to present this *Annual Report on Technology Transfer and Related Technology Partnering Activities at the National Laboratories and Other Facilities for Fiscal Year (FY) 2006*. The *Report* is prepared in accordance with the requirements of the Technology Transfer and Commercialization Act of 2000 [15USC 3710(f)1].

In FY 2006, DOE and its laboratories and facilities negotiated and executed 12,437 technology transfer-related transactions. These transactions included 631 new or active Cooperative Research and Development Agreements (CRADAs); 2,416 Work-for-Others Agreements involving non-Federal entities (NFEs); 5,916 licenses of intellectual property; and 3,474 user facility agreements. In addition, DOE national laboratories and facilities disclosed 1,694 inventions; filed 726 patent applications; were issued 438 patents; and logged more than 351,000 downloads of their copyrighted open-source software. Associated with these activities, DOE's laboratories and facilities reported $251.1 million in Work-for-Others for NFEs, $44.3 million of "funds-in" for CRADAs, $35.6 million in licensing income and nearly $18.3 million in earned royalties.

These activities evidence a robust technical enterprise, enabled by DOE outreach and technology partnering. While these activities are intended to facilitate research and innovation and encourage the development and transfer of emerging technologies, they also contribute to DOE missions and strengthen the technical competencies of DOE's laboratories and facilities. The extent of this work is a reflection, as well, of the continued confidence in DOE on the part of thousands of private partners who work with DOE in these ways. This *Report* describes these activities and outlines DOE's procedures for ensuring appropriate management and oversight of their conduct, in accord with prevailing policy and authorities.

This year's *Report* presents a special feature on the laboratories' collaborations with early-stage investors such as venture capitalists. In addition, Appendix B provides 27 examples of recent and successful technology partnerships and their outcomes. These outcomes span a broad range of research areas and DOE missions. Highlights include new technologies for energy supply and efficiency, homeland security, occupational safety, and medicine and health.

Finally, I would like to acknowledge the valued role played by the many professional practitioners of technology transfer throughout the DOE complex. I encourage them and their management to continue this excellent work. The resulting contributions add significantly to our Nation's economic competitiveness and to DOE's mission accomplishment.

Karen A. Harbert
Assistant Secretary
Office of Policy and International Affairs

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CHAPTER 1

OVERVIEW AND HIGHLIGHTS

The transfer of Federally developed technologies and capabilities to non-Federal technology partners, including private firms, has been an aim of Government policy since the passage of Bayh-Dole (P.L. 96-517, as amended by P.L. 98-620) and Stevenson-Wydler (P.L. 96-480) technology transfer legislation in the early 1980s. In 1989, the National Competitiveness Technology Transfer Act (P.L. 99-502) strengthened this aim by establishing technology transfer as a mission of Federal R&D agencies, including the Department of Energy (DOE). DOE has since encouraged its laboratories and production facilities to enter into technology partnering activities with non-Federal entities, as appropriate, using a variety of mechanisms, including cooperative research and development agreements (CRADAs). DOE has also authorized its facilities to patent and license intellectual property (IP) that may arise from DOE research and development (R&D) and collect and dispose appropriately of related royalties and fees.

Today, technology partnering is an active and significant component of DOE's overall mission, particularly in areas associated with its scientific, engineering and related technical activities. As authorized by DOE through provisions in its management and operating (M&O) contracts, technology transfer is now carried out at all 12 of DOE's national laboratories and at 10 other DOE research and/or production facilities. Broadly defined, technology partnering is a significant mechanism for the DOE laboratories and facilities to engage non-Federal entities in partnering arrangements in order to advance the process of technology development and commercialization. Motivated by mutual self-interest, and notably without transfer of Federal funds to the non-Federal partner, these arrangements provide means for collaboration and cooperation between DOE and the private sector, leverage resources and serve as useful alternatives to traditional contracting.

For DOE, technology partnering is important to the vibrancy of DOE's technical competencies at its research laboratories and facilities. DOE cannot afford to home-grow or replicate all the required skills in isolation inside its own fences. In order to accomplish its mission, DOE must have access to the rapidly evolving technical expertise and commercial technology of selected non-Federal entities, in effect "reverse technology transfer," that is transferring know-how and technology from the private sector to the Federal sector. Also, DOE laboratories and facilities create and own intellectual property, which can only be diffused into society for public benefit if developed further and commercialized. Non-Federal entities often have more experience in getting this goal accomplished successfully. DOE needs ways to partner with these firms.

At the same time, private firms and other non-Federal entities have found that DOE's research laboratories and facilities can provide, to the benefit of their own objectives, valuable and often unique problem solving capabilities. They are also interested in building long-term relationships with DOE that pay dividends over time. Technology partnering can enable and facilitate the productive leveraging of different but aligned motivations, benefiting both DOE and its partners, in addition to furthering Federal missions and national priorities.

Technology Partnering Goals

DOE Order 482.1 governs technology partnering at its laboratories and facilities. In concert with the relevant statutes in this area, this Order establishes technology transfer as a mission of DOE and its facilities and sets the policy context in which partnering is authorized to take place. The Order requires, for example, its practitioners to have a public purpose (e.g., a DOE mission) and to abide by certain procedures to ensure fairness of opportunity and protect DOE against potential excesses.

The DOE Order assigns roles and responsibilities to various DOE organizational elements for the oversight, management and administration of DOE facility technology partnering activities. To the extent that they are consistent with the terms of the facility contract, and its delegation of authority for technology transfer and partnering, the DOE Order also sets forth a series of broad purposes for such activities:

- Facilitate the efficient and expeditious development, transfer, and exploitation of Federally owned or originated technology to non-DOE entities for public benefit and to enhance the accomplishment of DOE missions;

- Leverage DOE resources, through its programs and facilities, through partnering; and

- Ensure fairness of opportunity, protect the national security, promote the economic interests of the United States, prevent inappropriate competition with the private sector, and provide a variety of means to respond to private-sector concerns and interests about facility technology partnering activities.

Technology Partnering Activities

Technology partnering can mean many things – technical assistance to solve a specific problem, use of unique facilities, licensing of patents and software, exchange of personnel, and cooperative research agreements. The most appropriate mechanism will depend on the objective of each partner. The most commonly used technology transfer mechanisms are described below:

- *Intellectual Property*. Identifying and protecting intellectual property made, created, or acquired at or by a DOE facility. This includes new invention disclosures; creation and filings of patent applications; patent issues, and associated monitoring and reporting.

- *Cooperative Research and Development Agreements*. Negotiating all aspects of and entering into Cooperative Research and Development Agreements (CRADAs), performed under the National Competitiveness Technology Transfer Act of 1989. Such agreements focus on mutually beneficial collaborative research. They may involve resource commitments by each partner for its own use, or resource commitments from the non-Federal partner to the Federal partner, but no resource commitments from the Federal partner to non-Federal partner.

- *Licensing*. Negotiating and entering into license agreements and bailments that provide rights in intellectual property made, created, or acquired at or by a DOE facility, which is controlled or owned by the contractor for that facility. A license transfers *less* than ownership rights to intellectual property, such as a patent or software copyright, to permit its use by the licensee. Licenses may be exclusive, or limited to a specific field of use, or limited to a specific geographical area. A potential licensee must present plans for commercialization. Royalties and income may be associated with the licensing.

- *Work-for-Others*. Performing work for non-Federal sponsors under DOE Order 481.1. WFO agreements permit reimbursable work, mostly research and development, to be carried out at DOE laboratories or facilities. This work is usually categorized into that for Federal agencies and non-Federal entities (NFE). It is the NFE work that is of interest to technology partnering in this report. For proprietary R&D conducted for NFEs, the Federal laboratory or facility is reimbursed for the full cost of the activity. If the work will be published, cost may be adjusted. Intellectual property rights generally belong to the NFE, but may be negotiated.

- *User Facilities*. Making available laboratory or weapon production user facilities. User facility agreements permit non-Federal entities to conduct research and development at a laboratory or use a particular scientific facility or instrument. For proprietary R&D, the laboratory is reimbursed for the full cost of the activity. If the work will be published, cost may be adjusted. Intellectual property rights generally belong to the investigator.

- *Technical Consulting*. Technical consulting usually takes the form of technical assistance to small businesses, undertaken in response to an inquiry or request for such assistance from an individual or organization seeking knowledge, understanding or solutions to a problem, or means to improve a process or product. The extent of such consulting is often limited to a relatively low level of overall effort.

- *Personnel Exchanges*. These arrangements allow facility staff to work in a partner's technical facilities, or the partner's staff to work in the government laboratory, in order to enhance technical capabilities and/or support research in certain areas. Costs are typically borne by the sponsoring organization. IP arrangements may be negotiated as part of these exchanges.

Laboratories and Facilities Engaged in Technology Transfer

DOE authorizes 21 laboratories and facilities to conduct such technology partnering activities. Most of these laboratories and facilities have established formal technology transfer programs. Many also have staff dedicated to the facilitation of the administrative and negotiating processes involved in entering into agreements with non-Federal partners. This Report presents trends and analyses of the technology transfer activities at the aggregate level for DOE. It does not show individual facility data.[1]

[1] Considerable differences exist among the DOE laboratories and facilities. These differences consist of two main determinants: amount of R&D funding and type of R&D activity. Laboratories and facilities receive R&D funding from DOE's Cognizant Secretarial Officers (CSOs). Each CSO exercises primary oversight, management, and administrative responsibility for technology partnering activities at the laboratories and facilities under his or her respective cognizance.

The laboratories and facilities authorized by DOE to carry out technology transfer activities are listed below. These 21 entities constitute the scope of data included in this Report.

- Ames Laboratory
- Argonne National Laboratory
- Brookhaven National Laboratory
- Fermi National Accelerator Laboratory
- Idaho National Laboratory
- Kansas City Plant
- Lawrence Berkeley National Laboratory
- Lawrence Livermore National Laboratory
- Los Alamos National Laboratory
- National Energy Technology Laboratory
- National Renewable Energy Laboratory
- Nevada Test Site
- Oak Ridge National Laboratory
- Pacific Northwest National Laboratory
- Pantex Plant
- Princeton Plasma Physics Laboratory
- Sandia National Laboratories
- Savannah River National Laboratory
- Stanford Linear Accelerator Center
- Thomas Jefferson National Accelerator Facility
- Y-12 National Security Complex

Summary of Transactions

In FY 2006, DOE and its laboratories and facilities negotiated and executed 12,437 technology transfer-related transactions. These transactions include 631 new or active Cooperative Research and Development Agreements (CRADAs); 2,416 Work-for-Others Agreements involving non-Federal entities (NFEs); 5,916 licenses of intellectual property; and 3,474 user facility agreements. In addition, DOE national laboratories and facilities disclosed 1,694 inventions; filed 726 patent applications; were issued 438 patents; and logged more than 351,000 downloads of their copyrighted open-source software. Associated with these activities, DOE's laboratories and facilities reported $251.1 million in Work-for-Others NFEs, $44.3 million of "funds-in" for CRADAs, $35.6 million in licensing income and nearly $18.3 million in earned royalties.

A summary of FY 2006 technology transfer data for the DOE's laboratories and facilities is presented in Table 1. Data for the past five years is provided in Appendix A.

Accomplishments

There are numerous examples of technology partnerships that reflect the successful transfer of technologies out of the laboratory and into the marketplace. For FY 2006, 27 representative accomplishments are presented in Appendix B.

Table 1: Summary of FY 2006 Technology Partnering Activities at DOE National Laboratories and Facilities

Technology Transfer Data Element	FY 2006
1) Transactions and Activities	
CRADAs, total active in the FY	631
New inventions disclosed	1,694
Patents applications filed	726
Patents issued	438
Total Licenses; Active in the FY	5,916
• Invention Licenses	1,420
• Other IP (copyright, material transfer, trademark)	4,496
Licenses that are income-bearing	2,822
Work-for-Others Agreements, Non-Federal Entities, Active in FY	2,416
User Facility Agreements, Active in FY	3,474
2) Reported Income (Thousands of Dollars)	
Total Licensing Income Received	$35,572
• Invention (Patent) Licenses	$ 32,211
• Other Licenses	$ 3,362
Total Royalty Income Earned	$ 18,332

Organization, Management and Oversight

DOE exercises oversight, management and administration of its technology partnering activities at its national laboratories and facilities in three ways. First, the Energy Policy Act of 2005 (EPAct), Title X, Section 1001, calls for the appointment of a technology transfer coordinator at DOE. Second, DOE's secretarial officers and heads of associated field organizations, guided by the applicable statutes and DOE Orders, set policy, establish procedure and provide oversight and accountability for all technology partnering activities at the laboratories and facilities under their cognizance. Third, DOE's "matrixed" organizations, known as working groups, assist in its effort oversight by meeting regularly to coordinate, communicate and integrate these policies and practices into daily activity across all of the DOE sites. There are two DOE working groups. For DOE Headquarters and its operations and field offices, the Technology Transfer Working Group (TTWG) is composed of Federal employees appointed to represent their respective organizations. For the DOE laboratories and facilities, the Technology Partnerships Working

Group (TPWG) is composed of employees from DOE headquarters and operations and field offices and DOE laboratories and facilities.

Energy Policy Act of 2005

The Energy Policy Act of 2005 (EPAct), Title X, Section 1001, states that the Secretary of Energy shall appoint a technology transfer coordinator to serve as the "principal advisor to the Secretary on all matters relating to technology transfer and commercialization." The Under Secretary for Science is studying the qualifications and activities required to fully implement this statutory requirement (Section 1001). Currently, the Department is reviewing a number of alternatives for the coordinator functions, responsibilities and organizational structure. `In the near future, the Department will determine the appropriate steps to take to implement Section 1001.

DOE Technology Transfer Working Group

At DOE Headquarters, the Technology Transfer Working Group (TTWG) is comprised of about 43 Federal employees engaged in the oversight of technology partnering or transfer activities within their R&D programs elements at DOE Headquarters, or the administrative elements at the DOE Operations offices. The TTWG provides an agency wide forum for exchange of information on current activities and a focal point, when needed, for the review, development, and integration of technology transfer policies. The TTWG serves to inform DOE headquarters and its program offices about ongoing activities and emerging issues.

The TTWG meets monthly via a teleconference. Its agenda and meeting exhibits are prepared in advance and transmitted electronically to all TTWG members. The Director of the Office of Science and Technology Policy, in DOE's Office of Policy and International Affairs, chairs the TTWG, which is co-chaired by the Assistant General Counsel for Technology Transfer and Intellectual Property, in DOE's Office of General Counsel. In addition to the 43 Federal members of the TTWG, a number of leading technology transfer managers and practitioners of the DOE laboratories and facilities, including those elected to the Technology Partnership Working Group executive committee, are regularly invited to participate. Through these means, the TTWG builds, maintains and regularly exercises a network of communications among professionals in the Headquarters and the field.

DOE Technology Partnerships Working Group

The field-led DOE Technology Partnerships Working Group (TPWG) is comprised of about 330 DOE-complex technology partnering practitioners. An executive committee comprised of six annually elected members, three from DOE operations and field offices, and three from DOE laboratories or facilities, lead the TPWG. The executive committee meets periodically to set and revise an annual program of activities believed to be useful to TPWG members. The executive committee also participates in the TTWG teleconferences.

The TPWG serves to address common needs of technology partnering offices and professionals across the DOE complex and facilitates in the sharing of best practices. It also provides services to the TTWG. It identifies field personnel who can contribute to ad hoc groups addressing current issues or planning activities, and ensures their completion. One way the TPWG accomplishes it mission is by organizing periodic training and information exchange sessions on technology partnering. It also serves as the coordinating body for gathering and compiling data for this Annual Report. The TPWG also helps organize the agenda and with guidance from the TTWG, acquires speakers for the DOE Annual Meeting on Technology Partnering. In May 2006, the TPWG combined their meeting with the annual meeting of the Federal Laboratory Consortium on Technology Transfer, held in Minneapolis, Minnesota.

Federal Multi-Agency Coordination and Liaison Activities

In addition, DOE is active in a number of interagency and liaison activities related to technology partnering. For example, the Director of DOE's Office of Science and Technology Policy, is designated as the DOE representative to the Federal Interagency Working Group on Technology Transfer, led by the Technology Administration, U.S. Department of Commerce. The IWG meets monthly and is attended by agency representatives and patent counsels from 17 Federal agencies. The IWG serves as an interagency forum for the exchange of information, as a means to raise and address issues and concerns and for coordination across the Federal agencies.

Federal Laboratory Consortium on Technology Transfer

The Federal Laboratory Consortium for Technology Transfer (FLC) is formally chartered by U.S. Congress to facilitate technology transfer in the United States. Its membership draws from about 250 Federal laboratories, including DOE's 22 technology transfer laboratories and facilities. In DOE, the Director of DOE's Office of Science and Technology Policy, and chair of DOE's TTWG, is the designated "agency representative" to the FLC. As required by statute, in FY 2006, DOE contributed $457,400, along with funds from other research and development agencies totaling $2,627,100, to the operations and management of the FLC. The FLC is supported by a contract between the National Institute of Standards and Technology, U.S. Department of Commerce, and the Universal Technical Resource Services, Inc., of Cherry Hill, New Jersey.

The DOE-designated agency representative of the Office of Policy and International Affairs participated in several FLC Board Meetings and the FLC annual meeting in Minneapolis, Minnesota in May 2006. The DOE representative also coordinated the update and certification of voting membership lists from DOE laboratories (one voting member each), and voted in the annual elections.

DOE Technology Transfer Website

DOE maintains a technology transfer website, as part of the Secretary of Energy's e-government initiative. The website provides the public with information on DOE's technology transfer policies, procedures, and activities. It enables public access to information regarding technologies available for licensing from the DOE Laboratories and Facilities, and serves as a comprehensive reference for technology transfer activities. The website can be found at http://techtransfer.energy.gov/. In FY 2006, there were 8,634 "hits" on the website.

Alternative Dispute Resolution

DOE's Office of Dispute Resolution, in DOE's Office of General Counsel, provides assistance to DOE national laboratories and facilities regarding the use of alternative dispute resolution in a number of areas including: contract, environment, grant and whistleblower cases. The Office also works directly with the individual ombuds at sites throughout the DOE complex to resolve intellectual property disputes at the earliest possible stage. Because non –Federal partners are often not familiar with Federal statutes and rules governing technology partnering, there is opportunity for confusion and misplaced expectations. It is important for DOE to communicate and to be sensitive to potential complaints and disputes.

In FY 2006, ombuds at DOE's national laboratories and facilities were involved in 13 potential disputes involving CRADAs, patents, licenses, Work-for-Others, or other issues. Five of these issues were resolved, and eight are still pending.[2]

The overall rate of incidence of disputes is considered low, in light of the total number of partnering arrangements of one kind or another initiated or continued each year between a DOE laboratory or facility and a non-Federal partner. Every such arrangement may be seen as an active engagement with a partner, and an opportunity for a dispute if not handled properly. In FY 2006, there were 12,352 such active arrangements, either new or continuing.

Multi-Year Trends in Key Indicators

In order to understand better the dynamics of technology transfer and technology partnering activities across the DOE complex, it is useful to examine a number of multi-year trends of key indicators. While the data sources vary and span various periods reflecting data availability, they do provide an opportunity to make some interesting observations on trends and patterns that develop. The indicators selected for examination include collaborative research and development agreements, licenses, and licensing income.

Research and Development Agreements with Industry

Cooperative Research and Development Agreements (CRADAs), Work-for-Others Agreements (WFOs), and User Facility Agreements are used by the DOE national laboratories and facilities to collaborate with industry partners on research and development (R&D) agreements. These technology partnerships involve laboratory scientists and industry partners working together, and provide an opportunity for technology development and maturation. Furthermore, these agreements provide a mechanism for industry partners to gain greater experience with the technical capabilities at the national laboratories and often can lead to follow-on research projects that can be mutually beneficial to both the laboratory and the industry partners.

[2] Data provided by DOE's Office of Dispute Resolution, January 25, 2007.

User Facilities are advanced scientific facilities, equipment, software, and the expertise that are available at DOE laboratories for the technical and scientific community. These facilities are intended to serve the research needs of the national laboratory scientists and, at the same time, encourage participation by industry and universities. DOE's Office of Science oversees a number of designated User Facilities; the National Nuclear Security Administration (NNSA) also oversees a number of 'Technology Deployment Centers/User Facilities'. All such User Facilities have been authorized to utilize special intellectual property provisions in their user agreements. Besides these officially designated User Facilities, some of DOE's national laboratories also operate other facilities that are in support of their laboratory mission. These laboratories frequently make these facilities available to industry and universities for research.
Figure 1 shows the trends for CRADAs, WFOs, and User Facility Agreements since 1992. One can see that the number of active CRADAs grew rapidly to just over 1,600 by FY 1996. After FY 1996, there was a precipitous drop in new CRADAs, and, by FY 2001, there were only 558 active agreements. Since that time, the number of active CRADAs has remained steady, averaging around 640 active agreements each year.

From Figure 1, one can see CRADAs initial growth followed by sharp decline after 1996. During this period, the numbers of CRADAs correlated closely with the federal funding allocated to support of CRADAs. In the early 1990s, Congress provided dedicated CRADA funding through the Technology Partnership Program and the Laboratory Technology Research Program. The combined Technology Partnership Program and the Laboratory Technology Research Program funding peaked at $261 million in FY 1995, but declined by zero in FY 2004. In recent years, despite the fact that there is no longer federal funding for CRADAs, their number has remained steady due to the use of "funds-in" CRADAs. In this type of CRADA, the industry partner pays for 100 percent of the costs for the laboratory's staff, facilities and equipment. In FY 2006, for example, about $44.3 million of private sector funds were received by the DOE laboratories and facilities for "funds-in" CRADAs.

In contrast to a decline in the number of active CRADAs, Work-for-Others Agreements with non-Federal entities (NFEs) has seen a consistent increase since 1992 (see Figure 1). The WFOs grew at a robust pace, with an accompanying influx of funds from businesses and other non-Federal entities to the national laboratories. In effect, WFOs have replaced CRADAs as the primary means for funding R&D projects with industry.

Figure 1 also shows that User Facility agreements have experienced substantial growth since the early 1990s. Despite their decline in FY 2004 and 2005, the recent 2006 data indicates that the level of activity in such agreements will remain high. In FY 2006, there were 3,470 active User Facility Agreements.

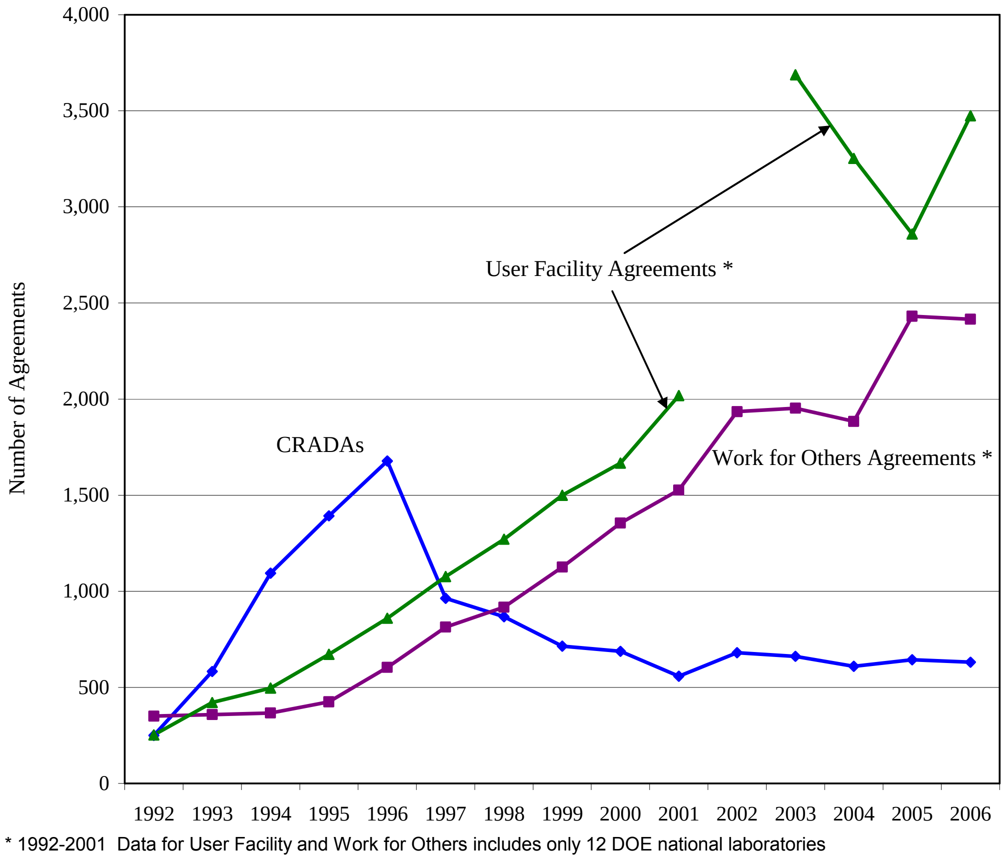

Figure 1: Trends in CRADAs, Work-for-Others Agreements, and User Facility Agreements

Licenses and Licensing Income

Figure 2 presents data on licenses and income from licenses from FY 1999-2006. The total number of active licenses is divided into two classes: patent (invention) licenses and other licenses. Other licenses include copyrighted software (not including open source software licenses, which are also copyrighted software), biological materials and other forms of intellectual property. Copyright licenses make up the bulk of “other IP” licenses.

The steady growth in licensing activity shown in Figure 2 is due principally to the growth in copyright licenses. The vast majority of copyright licenses are associated with published software. The number of active licenses has more than tripled since 1999, growing from 1,922 (FY 1999) to 5,916 in FY 2006.

Figure 2 also shows the growth in income from licensing agreements, which is consistent with the growth in the number of license agreements. Licensing income has also tripled over the past 6 years, growing from almost $12 million in FY 1999, to about $36 million in FY 2006.

Licensing income may be used by laboratories and facilities a number of ways provided it is consistent with DOE policy, their management and operating (M&O) contract provisions and the goals of each laboratory or facilities' institutional management plan. In general, licensing income is divided among the inventors, other contributors, and the laboratory. The inventor/contributor share typically ranges from 15-35 percent, with universities generally paying a higher share than research institutions and corporate M&O contractors. For the laboratory share, a portion also is distributed to the laboratory division or program where the inventions are created. This income is typically used for education/training, supporting other R&D projects that are not sponsored by DOE programs, and in, some cases, technology maturation. A final portion of the laboratory income is distributed to different offices at the laboratory for various, but related purposes, including a portion to the laboratory's technology transfer office for its use in technology maturation for regional economic development; and for projects.

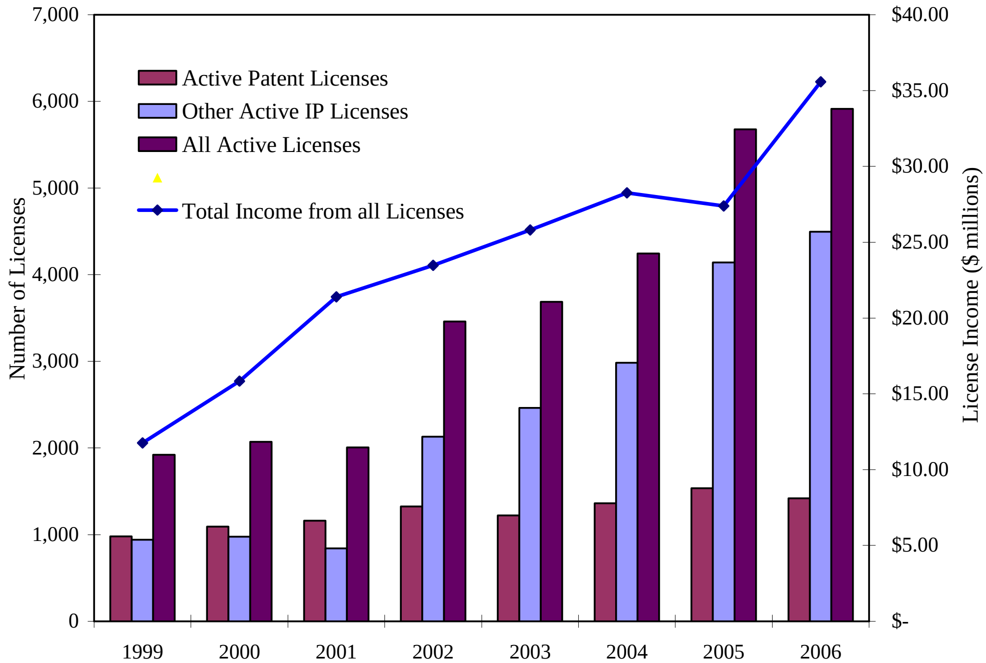

Figure 2: Trends in Licenses and Licensing Income

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CHAPTER 2

VENTURE CAPITAL AND THE VALLEY OF DEATH: EXPERIENCES FROM THE NATIONAL LABORATORIES

Technology transfer is a burgeoning enterprise for DOE and its national labs. DOE laboratories and facilities reported $251.1 million in Work-for-Others from non-Federal entities, mostly private firms); $44.3 million of "funds-in" for CRADAs from non-Federal enterprises; $35.6 million in licensing income; and nearly $18.3 million in earned royalties. In addition, DOE's M&O contractors are authorized to use a portion of laboratory overhead funds (0.5% at most laboratories, 1.0% at NNSA laboratories) to protect intellectual property, engage in partnering agreements, and develop and market technology.

Each year DOE identifies dozens of technology transfer "success stories" by national laboratories and other facilities in its annual report on technology transfer. In this year's Report, 27 success stories are provided in Appendix B. In addition, more than 100 DOE scientists, engineers and technology transfer practitioners were recognized for outstanding achievement in technology transfer by the Federal Laboratory Consortium on Technology Transfer.

Despite these impressive statistics, DOE national laboratories face difficulties in helping to commercialize their technologies. One common explanation often heard is that there is a funding gap" or negative cash flow during the critical period after programmatic research and development (R&D) funds decline and before traditional commercial financing becomes available.

This section of the Report looks at one possible tool -- public-private partnerships with seed and venture capital firms – that may address an endemic problem of the need for technology maturation funding for energy technologies that have been developed at the DOE national laboratories. Such a tool may provide greater yields in DOE R&D investments in energy technologies.

The paragraphs that follow provide an overview of the current practices at DOE national laboratories. Although not described here, it is recognized that some other federal agencies, namely the Central Intelligence Agency, the National Aeronautical and Space Administration, and the Department of Defense have in place or have recently launched other public-private partnership arrangements that may serve as models for DOE. While the problem of a lack of early stage technology development funding is apparent for other agencies' missions, the focus here is on advanced energy technologies that can contribute to America's energy security through reliable, clean, and affordable energy.

The Funding Gap

The early stages of a technology-based start-up business often suffer from negative cash flow, as shown in Figure 3. This funding gap, often called the "valley of death," is a negative cash flow environment. The negative cash flow occurs because the investment needed for the development of the technical and non-technical elements of the business exceeds the income from the company's operations (sales of products and/or services). Cash flow is a particularly large problem where a large capital investment (requiring significant external financing) is needed to develop manufacturing and distribution, as is typical in a complex technology venture. Hence, in the valley of death, equity financing will be needed for many technology-based start-up companies, because these companies have limited ability to service debt.

In the early stages, DOE R&D investments provide the funding necessary for research and technology creation. As the R&D funding ends and the fruits of the R&D investments begin to show promise in the lab, the technologies move into an early stage of development where private sector investments are needed. It is at this point where additional capital is necessary if the nascent technology is to further evolve. Sources of early stage capital can either come from entrepreneurs, angel investors, venture capitalists, or other sources. As is often the case however, the technology has evolved to a point to where DOE R&D investments are exhausted and additional capital is needed.

As technologies enter into the valley of death, risks in the technology and markets are most apparent. This is the point where technology "maturation," i.e. scale-up and performance verification information, is needed to attract investment capital. Furthermore, there is a need to understand and demonstrate that there is, or can be, strong markets for the technology, along with a strategy for reaching those markets. Finally, it is in the early stage of this valley of death that product maturation, or the need to transform the technology into early market-driven, market-ready products including prototypes, is necessary. This is the point where "seed" capital investments are most needed for the maturing of early-stage technologies to successfully commercialize new energy technologies.

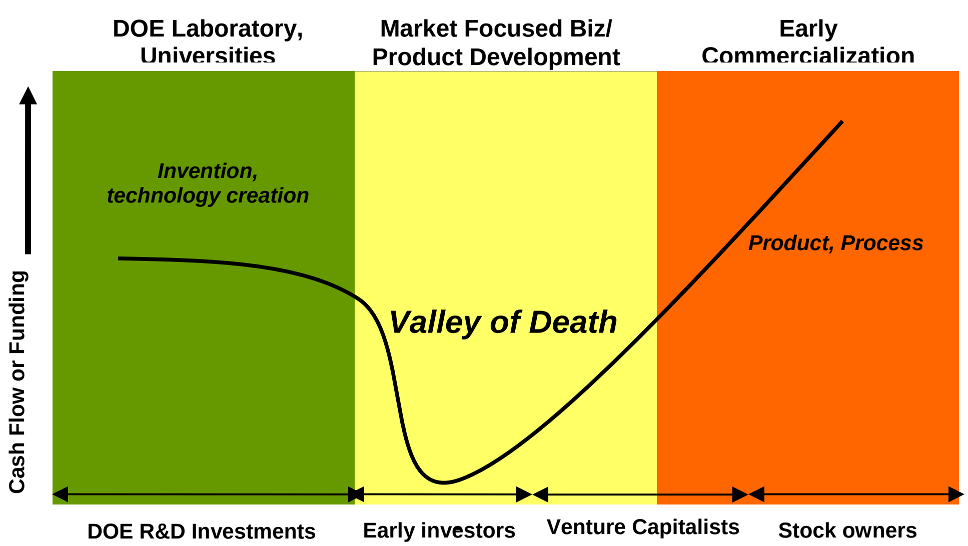


Figure 3. The Funding Gap, or "Valley of Death"

Private Sector Financing

In the valley of death phase, private sector financing is obtained from early investors or venture capitalists. These investors generally have a near term perspective with a market-oriented firm with a new product. Their primary motivation is to earn a profit.

In the early stage, angel investors, seed-funding organizations, and early-stage venture capitalists are most accessible to the start up company. An "angel investor" is a wealthy individual investor that is a good source for early stage capital because significant capital is not generally available for early stage start up companies.

Investment funds generally follow certain stages of investments. "Seed" funds used for proof of concept and qualification for start up are typically on the order of $25,000-500,000. "Start-up" financing involves product development and initial marketing efforts, with investments by angels and early-stage venture capital firms. Typical amounts for start-up financing are in the ranges of $500,000 - $3,000,000. In later stages of product development, venture capital firms make investments in the range of $1.5 – 30 million.[3]

Venture Capitalists (VCs) invest in businesses with expected growth in its value and the underlying investment. The VC expects its investment will provide a significant return to compensate for the risk. While a capital investment in a public company may have an expected return of 10-15% (historical market returns), the associated risk of a new venture drives VC's expectation to a 25% or more return based on the specifics of the company.[4]

The VC's raises funds from private investors, who are limited partners in the VC firm. The VC raises funds (see fundraising in Figure 4) from these limited partners, with specific objectives in mind (e.g. including those related to types of technologies, sizes of investments, stage of development, and risk profiles, etc.) and for a specific fund. An example composite makeup of the limited partners is provided in the table shown in Figure 4.

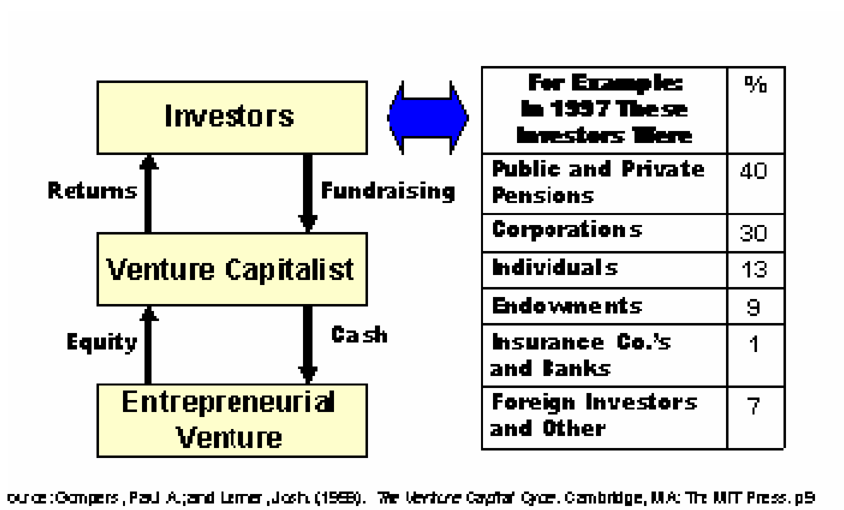


Figure 4: Venture Capital Process
Source: Personal Communication with Lawrence Murphy, National Renewable Energy Laboratory.

Once the investors agree to fund the VC's, according to the stated

[3] Murphy, Lawrence M., Julie Brokaw, and Chris Boyle (2002), *Transitioning to Private-Sector Financing: Characteristics of Success,* NREL/MP-720-31192, National Renewable Energy Laboratory.
[4] *Ibid*, p. 10

objectives they usually don't get involved in individual entrepreneurial ventures. But if the VC wants to stray from the original plan, they must get approval from the limited partners. The limited partners do not provide a lump sum cash amount, but rather provide funds as investments are made in the companies.

In a particular fund there may be a dozen or more investments made in individual entrepreneurial ventures, and they may be syndicated with other VC's. While the VC's provide cash to the entrepreneurial venture they take equity in return, and they ultimately sell their equity stake through an Initial Public Offering (IPO), merger, acquisition, or other buy-out transaction.

The VC's get paid a management fee which varies, but typically it is approximately 2 percent of the funds under their management. On average, about 60 percent of the investments typically made by VC's are not profitable, and the VCs make the major proportion of their profits from 10-15 percent of their investments. And while they look for 40 percent return on each investment, they typically get significantly less on the whole portfolio. A good fund portfolio will return 25-27 percent (internal rate of return).

The Department's Management and Operating (M&O) contractors at DOE national laboratories have, for some years now, engaged in venture capital markets. A summary of experiences are presented in the next section.

Experiences with Venture Capital Firms

In recent years, experiences at DOE national laboratories have demonstrated new and innovative approaches to working with VCs towards technology deployment and commercialization. While many of the national laboratories have implemented means of technology maturation funding, the focus here is on relations with VC. Three experiences have been identified for illustration; Battelle Ventures, National Renewable Energy Laboratory's Industry Growth Forums and Clean Energy Alliance, and the Technology Ventures Corporation.

Battelle Ventures

Battelle Ventures, L.P., (BV) is a $150-million venture capital fund based in Princeton, New Jersey, with an affiliate $35 million fund named Innovation Valley Partners located in Knoxville, Tennessee. Battelle Ventures, established in August 2003, seeks to initially invest in companies at early stages of development, ranging from initial start up of technology-based enterprises at the laboratory level through early revenue.

While Battelle Memorial Institute (BMI) of Columbus, Ohio is BV's sole limited partner, the fund is independent and its managers are not employed by BMI. Through the relationship, Battelle Ventures enhances and adds value to its portfolio of companies by leveraging the technologies and expertise of BMI and the National Laboratories it manages or co-manages for DOE, including Brookhaven National Laboratory, Idaho National Laboratory, the National Renewable Energy Laboratory, Oak Ridge National Laboratory, and Pacific Northwest National Laboratory.

Battelle Ventures has three major thrusts. Like most venture capital firms, BV looks for technologies that solve a key problem significantly better than existing technologies in large and growing markets. If it identifies a platform technology of potential interest for a start-up company, BV may provide maturation funding to the national laboratory to further the technology development. In parallel, the firm will seek industry-relevant management expertise in developing a business plan for the potential new business. If the technology development and the business plan meet BV's investment criteria, a start-up company will be created and funded by BV. The company will then negotiate a license with the national laboratory for the technology of interest.

BV's approach to commercializing national laboratory technologies goes beyond the traditional spin-off model. Through its relationships with the technology transfer organizations at the national laboratories, the firm is introduced to national laboratory licensees seeking funding and evaluates potential investments in those licensees. By providing funding to fledgling startups which have licensed national laboratory technology, BV plays a vital role in helping these companies realize their potential and bring the licensed technologies to market.

In a third approach, BV is referred to companies through a variety of sources, including its venture capital contacts, entrepreneurs, or by the national laboratories themselves. When these companies meet the firm's investment criteria, BV will identify areas of expertise at the national laboratories that could potentially help the start-up company in its development. The introductions facilitated by BV between companies and national laboratories have the potential to lead to contractual or licensing opportunities for the national laboratories and thus provide another path to commercialize national laboratory expertise or technology.

From its inception through the end of 2006, BV has invested in four companies that have licensed technology from Battelle Memorial Institute or the national laboratories. These include: two from Pacific Northwest National Laboratory (PNNL), one from Oak Ridge National Laboratory, and one from Battelle Memorial Institute. The firm is currently in negotiations to fund its first start-up company based on technology from the National Renewable Energy Laboratory. Battelle Ventures has made an additional eleven investments in companies that seek to leverage the capabilities of Battelle Memorial Institute and the national laboratories to enhance their technology development. Of the fifteen total investments, three are energy companies, four are in life sciences and eight provide homeland security solutions.

To date, the BV has had one successful exit, the sale of SafeView (a PNNL licensee) to L-3 Communications, in March 2006. Battelle Ventures' funding allowed SafeView to achieve milestones which made it attractive for acquisition. The L-3 acquisition will allow SafeView to further scale its business, continue to deliver licensing revenues to PNNL, and more effectively transition the Lab-developed technology to the commercial marketplace.

Industry Growth Forums and Clean Energy Alliance

The National Renewable Energy Laboratory (NREL) has developed several innovative approaches to entrepreneurial development and venture capital investments through their Industry Growth Forums and the Clean Energy Alliance.

Industry Growth Forums. Industry Growth Forums (IGF) bring together start-up clean energy companies, venture capitalists, and senior business executives to catalyze learning about business growth strategies and facilitate strategic business partnerships. NREL led in the creation and development of these forums and today, the forums are primarily sponsored by a large array of investment firms and through registration fees; with NREL providing a small amount of in-kind sponsorship. The IGF provide a venue for companies to present and receive feedback on summary business plans before a panel of VCs and other business executives interested in the industry, businesses, and technologies discussed.

The IGF are designed to provide an opportunity for companies to improve their business concepts and overall strategies. In more traditional venture forums, presenters may get only 10-12 minutes to make a business case, and frequently receive little feedback. The IGF, by contrast, involve more than a half hour of formal interaction and additional time for informal interactions, thus providing small renewable energy companies a more meaningful opportunity to explore financing and partnership options and receive constructive feedback from venture financiers and senior business managers.

Forum evaluation panels are made up primarily of established VCs that bring a high level of experience and credibility to presentation and feedback sessions. Participating VCs introduce presenting companies to the "due diligence process," a process of proving assertions and assumptions captured in the business plan that these companies will experience with increasing frequency as they grow their businesses and expand their networks to include a wider range of strategic partners.

Other Forum evaluation panel members, such as senior executives from utilities and large businesses, bring the perspectives of the user community to presentation and feedback sessions. They also represent a source of potential partnerships for presenting companies, able to bring strategic resources to start-ups and to provide credibility within the investor community.

As of the end of 2006, there have been a total of 85 distinct investments, totaling approximately $660 million, in the companies that have presented at the IGF. Of this $660 million, approximately $571 million, or 86 percent, was raised from the private sector, while the remainder was raised from public sector sources. NREL was able to confirm 44 distinct private sector investments, including 39 private equity raises and five Initial Public Offerings (IPOs), indicating the majority of presenters remain early- to mid-stage companies prior to the infusion of additional capital. The average size of these private sector investments was $12.97 million but the median investment was $3.5 million, indicating the distribution is skewed by a few large investments. The mean and median of the 41 public sector investments are $2.18 million and $750,000, respectively, indicating a similar skew in public sector investments.

Clean Energy Alliance. The Clean Energy Alliance of Clean Energy Business Incubators, a non-profit corporation established in 2000 by NREL, is an alliance of ten leading business incubators from across the country. The Clean Energy Alliance is dedicated to helping startup and developmental clean energy businesses grow. Clean Energy Alliance Incubators help client companies refine their business cases and develop their enterprises, thus making them more attractive to private sector investors. Through the Incubators, the Alliance helps provide a larger source of lower risk investment opportunities for private sector financiers, while simultaneously providing jobs and economic development for local regions, providing higher yield on R&D investments made by public and private sectors, and providing more rapid and certain commercialization of clean energy technologies.

There are currently 104 clean energy companies from all over the country participating in the Clean Energy Alliance. Participation ranges from companies that are physically located in the incubator, to companies that receive assistance and guidance via a virtual relationship. These 104 companies employ 2,378 workers dedicated to the development of clean energy technology. There are also 69 graduate companies that no longer require incubation services and are self-sufficient.

More than $173 million in capital has been raised by clean energy startups over the past four years. This includes both public and private capital in the form of angel investors, VC, Small Business Innovation Research grants, and other investments. These clean energy startup companies have generated over $254 million in revenue – inclusive of royalties on technologies.

Another important factor is the money leveraged by the incubators. In the past three years, incubators have received $39.2 million from Federal sources (usually passed through state level initiatives and organizations), $10.8 million from state sources, and $21.6 million from other sources (private, city, county, etc.) This money helps to facilitate the incubation process and provide an additional catalyst for the profitable commercialization of clean energy technology. In addition, NREL is working to establish the framework for a "virtual incubator" in Golden, Colorado; the Clean Energy Innovation Center. The Center will support the Rocky Mountain technology-based small businesses and will provide access to NREL's facilities. The expected impact will be to stimulate the growth of clean energy companies in the Rocky Mountain range region.

Technology Ventures Corporation

Technology Ventures Corporation (TVC) was founded in 1993 by Lockheed Martin Corporation as a non-profit, tax exempt, charitable foundation, with a focus on commercializing technologies from Sandia National Laboratories. In 2002, TVC entered into a Cooperative Agreement with the National Nuclear Security Administration (NNSA) to expand TVC's commercialization operations to support Lawrence Livermore National Laboratory, Los Alamos National Laboratory, and the Nevada Test Site and expand its educational, market research, and other resources.

TVC's objective, in partnership with NNSA, is to form and/or expand high-technology businesses based on technologies from publicly funded science-based research and development institutions, creating new jobs. TVC works with laboratory scientists to help them through all the steps necessary to start a technology-based business, including: entrepreneurial training, business plan development, funding proposal preparation, market research, and personnel recruitment. TVC also works extensively with (valley of death) investors to help them find and evaluate quality investment opportunities in technology-based businesses.

Since TVC began operations, it has facilitated 143 commercialization funding events, totaling over $686 million in seed and early stage (valley of death) funding, the formation of 85 new companies, and the creation of 9,056 new jobs. Since the agreement with NNSA began in 2002, TVC and NNSA have provided more than $355 million in seed and early stage funding and fostered 36 new companies, and the creation of 3,400 new jobs.

TVC engages a wide range of technologies, mirroring the breadth of technology within the DOE national laboratories, including: information technology, optics, micro-electronics, life sciences, and energy. In energy technologies, there have been 18 laboratory sourced or related energy technology companies resulting in 12 funding events, with seven being seed investment and five being post-seed investment, for a total of $74 million. TVC is also a founding member of the NREL's Clean Energy Alliance of Clean Energy Business Incubators. TVC's energy technology companies accounts for more than half the funding recorded by NREL's Clean Energy Alliance.

There are many examples where TVC clients have successfully attracted seed capital funds in their start up activities. One such example is Wellkeeper, Inc., which is commercializing a technology for remote monitoring of oil and gas wells. In July 2004, Wellkeeper became a TVC client, and in early 2006, it received a seed capital round of $1.2 million. Another example is Advent Solar, which is commercializing SNL's new solar cell technology. Advent has been a TVC client since 2003, and they presented at TVC's Equity Capital Symposium in May 2004. Advent first received seed round funding of $400,000, then received "A" round funding of $8 million, and completed a $30 million "B" round in late 2005. The total funding received to date by these two companies exceeds $39 million. Wellkeeper and Advent estimate they will together, employ about a thousand people by 2010.

Conclusion

Alternative means of attracting venture capital can help bridge the funding gap from when the technology emerges from the national laboratory until it becomes a viable commercial product. Not only can such capital accelerate the transfer of technology from the lab to the marketplace, but it also can increase both the yield on public sector technology investments and the pipeline volume of good financing deals to sustain the growing investment interest in advanced energy technologies. Key stumbling blocks that increase risk and inhibit early-stage private sector investment include high technology and product risk, underdeveloped (and often poorly defined and understood) markets for the technology, and long times to market. The experiences described in this section are a first step in addressing these difficulties.

APPENDIX A

DEPARTMENT OF ENERGY'S TECHNOLOGY TRANSFER ACTIVITIES, FISCAL YEARS 2002 – 2006

The Technology Transfer Commercialization Act of 2000 (P.L. 106-404) requires each Federal agency that operates or directs Federal laboratories (or engages in patenting or licensing of Federally owned inventions) to provide the Office of Management and Budget (OMB) with an annual report on its technology transfer plans and recent achievements. A copy is also provided to the Technology Administration Office of the Department of Commerce. The Secretary of Commerce then prepares an overall Federal assessment for the President and Congress based on the program information in these agency reports. Specific data requirements to be reported each year are established by the Department of Commerce.

In accordance with the OMB's reporting guidelines, DOE's technology transfer data for fiscal years 2002-2006 are shown in Table 2 below. The table continues on the following pages.

Table 2: Department of Energy's Technology Transfer Activities, Fiscal Years 2002-2006

	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006
• CRADAs, total active in the FY[1]	680	661	610	644	631
- New, executed in the FY	192	140	157	164	168
▪ Traditional CRADAs,[2] total active in the FY	--	Nr	Nr	Nr	Nr
- New, executed in the FY	--	Nr	Nr	Nr	Nr
▪ Non-traditional CRADAs, total active in FY	--	Nr	Nr	Nr	Nr
- New, executed in the FY	--	Nr	Nr	Nr	Nr
• Other collaborative R&D relationships					

(1) "Active" = legally in force at any time during the FY. "Total active" is comprehensive of all agreements executed under CRADA authority (15 USC 3710a).
(2) CRADAs involving collaborative research and development by a federal laboratory and non-federal partners.

Invention Disclosure and Patenting

• New inventions disclosed in the FY [1]	1,498	1,469	1,617	1,776	1,694
• Patent applications filed in the FY	711	866	661	812	726
• Patents issued in the FY	551	627	520	467	438

(1) Inventions arising at the DOE laboratories and facilities.

Licensing

Profile of Active Licenses					
	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006
• All licenses, number total active in the FY[1]	3,459	3,687	4,345	5,677	5,916
- New, executed in the FY	694	711	616	750	652
▪ Invention licenses, total active in the FY	1,327	1,223	1,362	1,535	1,420
- New, executed in the FY	206	172	168	198	203
- Patent licenses, total active in FY	1,327	1,223	1,362	1,535	1,420
- New, executed in the FY	206	172	168	198	203
- Material transfer (inventions), total active in FY	0	0	0	0	0
- New, executed in the FY	0	0	0	0	0
- Other invention licenses, total active in FY	--	--	--	--	--
- New, executed in the FY	--	--	--	--	--
▪ Other IP licenses, total active in the FY	2,132	2,464	2,983	4,142	4,496
- New, executed in the FY	488	539	449	553	449
- Copyright licenses	1,525	1,823	2,136	3,042	3,238
- New, executed in the FY	332	348	217	289	184
- Material transfer (non-inv.), total active in FY	581	604	794	999	1,110
- New, executed in the FY	153	180	208	229	228
- Other [2]	26	37	53	101	148
- New, executed in the FY	3	11	24	35	37

(1) "Active" = legally in force at any time during the FY.
(2) Bailment agreements, trademark, etc.

Profile of Active Licenses (cont.)

	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006
• All income bearing licenses [1]	2,523	2,523	3,236	2,549	2,822
- Exclusive	301	246	255	248	353
- Partially exclusive	136	235	638	287	283
- Non-exclusive	2,086	2,042	2,343	2,014	2,186
▪ Invention licenses, income bearing	1,123	1,056	1,151	1,148	1,245
- Exclusive	263	215	223	223	295
- Partially exclusive	123	196	189	244	245
- Non-exclusive	737	645	739	681	743
- Patent licenses, income bearing [2]	1,123	1,056	1,151	1,148	1,245
- Exclusive	263	215	223	223	295
- Partially exclusive	123	196	189	244	245
- Non-exclusive	737	645	739	681	743
▪ Other IP licenses, income bearing	1,400	1,467	2,085	1,402	1,540
- Exclusive	38	31	32	26	59
- Partially exclusive	13	39	449	43	38
- Non-exclusive	1,349	1,397	1,604	1,333	1,443
- Copyright licenses (fee bearing)	1,173	1,352	1,993	1,233	1,454
- Exclusive	29	25	30	25	58
- Partially exclusive	7	35	448	39	32
- Non-exclusive	1,137	1,292	1,515	1,169	1,364
- Other IP licenses	227	115	92	169	86
- Exclusive	9	6	2	1	1
- Partially exclusive	6	4	1	4	6
- Non-exclusive	212	105	89	164	79
• All royalty bearing licenses [3]	2,523	2,522	3,236	2,549	2,822
▪ Invention licenses, royalty bearing, number	1,123	1,056	1,083	1,148	1,245
▪ Patent licenses royalty bearing	1,123	1,056	1,151	1,148	1,245
▪ Other IP licenses, royalty bearing	1,400	1,467	2,085	1,402	1,540
- Copyright licenses (fee bearing)	1,173	1,352	1,993	1,233	1,454
- Other IP licenses	227	115	92	169	86

(1) "All income bearing licenses" are equal to the sum of "invention licenses" and "other IP licenses."
(2) For purposes of DOE reporting, "invention licenses" are the same as "patent licenses."
(3) "All royalty bearing licenses" are the same as "all income bearing licenses."

Licensing Management

	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006
• Elapsed execution time, licenses granted in FY (days)					
▪ Invention licenses					
- average (or median)	127	133	62	104	64
- minimum	8	8	0.5	1	1
- maximum	471	745	1,777	1,750	2,614
- Patent licenses					
- average (or median)	127	133	62	102	64
- minimum	8	8	0.5	1	1
- maximum	471	745	1,777	1,750	2,614
• Number of licenses terminated for cause in FY					
▪ Invention (Patent) licenses	77	35	31	21	29

Annual License Income ($ thousands)

	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006
• Total income, all licenses active in FY [1]	$23,477	$25,805	$27,252	$27,382	$35,572
▪ Invention licenses	$21,253	$23,670	$23,321	$24,226	$32,211
- Patent licenses	$21,253	$23,670	$23,670	$24,226	$32,211
▪ Other IP licenses, total active in the FY	$2,223	$2,136	$3,931	$3,156	$3,362
- Copyright licenses	$1,870	$2,101	$2,678	$3,140	$3,218
- Other					$143
• Total Earned Royalty Income (ERI) ($thousands)	$5,609	$6,612	$10,882	$12,443	$18,332
- Median ERI	$4	$3	$4	$4	$3
- Minimum ERI	$0.023	$0.003	$0.004	$0.004	$0.007
- Maximum ERI	$794	$913	$2,600	$1,752	$6,489
- ERI from top 1% of licenses	$1,550	$1,478	$3,977	$3,486	$10,063
- ERI from top 5% of licenses	$3,696	$3,789	$8,837	$8,933	$13,697
- ERI from top 20% of licenses	$4,571	$5,962	$12,743	$11,152	$16,262
▪ Invention licenses					
- Median ERI	$6	$5	$5	$5	$6
- Minimum ERI	$0.025	$0.003	$0.006	$0.005	$0.007
- Maximum ERI	$794	$913	$2,600	$1,752	$6,489
- ERI from top 1% of licenses	$794	$1,478	$3,977	$3,486	$9,502
- ERI from top 5% of licenses	$3,419	$3,197	$7,299	$7,571	$12,776
- ERI from top 20% of licenses	$5,068	$5,363	$10,729	$10,270	$15,499
- Patent licenses					
- Median ERI	$6	$5	$5	$5	$6
- Minimum ERI	$0.025	$0.003	$0.006	$0.005	$0.007
- Maximum ERI	$794	$913	$2,600	$1,752	$6,489
- ERI from top 1% of licenses	$794	$1,478	$3,977	$3,486	$9,502
- ERI from top 5% of licenses	$3,419	$3,197	$7,299	$7,571	$12,776
- ERI from top 20% of licenses	$5,068	$5,363	$10,729	$10,270	$15,499

(1) Total income includes license issue fees, earned royalties, minimum annual royalties, paid-up license fees, and reimbursement for full-cost recovery of goods and services provided by the lab to the licensee including patent costs.

Annual License Income ($ thousands) (con't)					
	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006
▪ Other IP licenses					
- Median ERI	1	1	$2	$4	$3
- Minimum ERI	$0.023	$0.010	$0.004	$0.004	$0.005
- Maximum ERI	$69	$168	$197	$233	$566
- ERI from top 1% of licenses	$69	$168	$197	$333	$568
- ERI from top 5% of licenses	$115	$316	$498	$502	$1,069
- ERI from top 20% of licenses	$197	$480	$660	$707	$1,427
- Copyright licenses [1]					
- Median ERI	2	1	$2	$4	$3
- Minimum ERI	$0.023	$0.010	$0.004	$0.004	$0.005
- Maximum ERI	$69	$168	$197	$233	$566
- ERI from top 1% of licenses	$69	$168	$197	$333	$568
- ERI from top 5% of licenses	$100	$272	$498	$502	$1,069
- ERI from top 20% of licenses	$187	$480	$659	$707	$1,427

Disposition of License Income ($ thousands)

• Income distributed [2] (thousands)					
▪ Invention licenses, total distributed	$16,423	$19,540	$18,622	$23,711	$25,931
- To inventors	$6,386	$5,624	$4,398	$5,267	$7,183
-To other	$10,036	$13,916	$14,224	$18,444	$22,143
- Patent licenses, total distributed	$16,423	$19,540	$18,622	$23,711	$25,931
- To inventors	$6,386	$5,624	$4,398	$5,267	$6,503
-To other	$10,036	$13,916	$14,224	$18,444	$19,428

Other Performance Measures Relevant to DOE					
Work-for-Others Agreements – Non-federal sponsors	1,934	1,952	1,884	2,431	2,416
User Facility Agreements	--	3,688	3,252	2,859	3,470
Open Source Downloads				205,000	351,322

(1) Data not requested from agency in previous years and not available.
(2) Income includes royalties and other payments received during the FY.

Other Notes
-- Data not requested from agency in previous years' reports.
Nr Data not reported by DOE

APPENDIX B

SELECTED ACCOMPLISHMENTS

There are many examples of technology transfer and industry partnering activities that reflect successful programs at DOE national laboratories and facilities. The following are examples of 27 successes, presented below to illustrate the range and nature of DOE technology transfer activities across the DOE complex. A brief description of each is included in the following pages.

- Advanced Process Engineering Co-Simulator
- Biorefinery Process for Making Ethanol
- Body Scanner Shapes-up Security and Fashion
- BROOM Speeds Clean Up
- Cancer Treatment Technology
- Carbon Explorer Monitors Ocean Carbon
- Detection Systems For Dirty Bombs
- Drill String Radar Technology
- Drug for AIDS Therapy
- Electron Beam Welding
- Enzymes for Producing Biofuels
- Fiber Optic Sensor for a Hydrogen Economy
- Fuel Cell Advances
- Grids and Collimators Produce Better X-ray and Nuclear Images
- High-sensitivity and Low-cost Infrared Camera Detectors
- LandScan Population Distribution Database
- Medical Isotope Testing
- MEMs Sensor Technology for Orthopedic Implants
- Multiport Dryer Paper Design Will Improve Paper Drying Process
- Open-Source Software for Power Generation
- Pocket-Sized Card Detects Explosives
- Removing Metal Contaminants from Materials
- Separating Organic Material into Value-Added Chemicals
- Starlight Information Visualization System
- Strategic Alliance for Advanced Energy Technologies
- Thermo Electron Partnership Protects America’s Ports
- Tire Pressure Sensing Technology

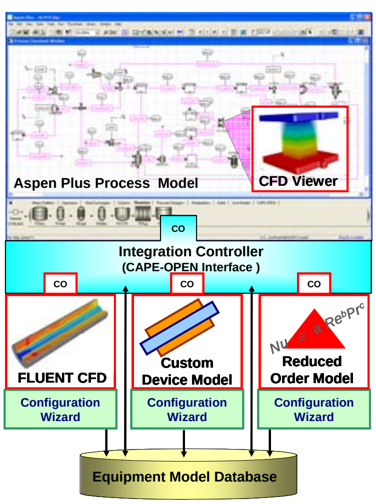
Advanced Process Engineering Co-Simulator

Advanced Process Engineering Co-Simulator (APECS), winner of an R&D100 and Federal Laboratory Consortium (FLC) Mid-Atlantic Region Technology Transfer award, was developed at the U.S. Department of Energy's (DOE) National Energy Technology Laboratory (NETL). The APECS is a tool to enable the process and energy industries to co-simulate aggressive performance and environmental targets for their production plants and simultaneously optimize them for the most profitable operation.

The process and energy industries manage some of the most sophisticated and expensive plants in the world, spending on the order of $600 billion annually in plant design, operation, and maintenance. APECS allows the industries to better understand and optimize overall plant performance with respect to complex thermal and fluid flow phenomena. These industries also face the challenge of designing next-generation plants to operate with unprecedented efficiency and near-zero emissions, while operating profitably amid cost fluctuations for raw materials, finished products, and energy. To achieve performance targets and at the same time reduce the number of costly pilot-scale and demonstration facilities, the designers of future plants must rely on high-fidelity computer simulations to design and evaluate virtual plants.

The APECS software technology provides the necessary level of detail and accuracy essential for virtual plant co-simulation by combining best-in-class process simulation and computational fluid dynamics (CFD) with high-performance computing and interactive, immersive, 3D plant walk-through virtual engineering software. At NETL, system analysts are applying APECS to reduce the time, cost, and technical risk of developing high-efficiency, nearly emission-free power plants, such as the coal-fired, gasification-based plant in the $1 billion, 10-year DOE FutureGen R&D Initiative.

The tools used by NETL to transfer the APECS technology included a DOE-funded cooperative R&D project and agreement among NETL; Fluent, the world's leading supplier CFD software and services; Aspen Technology, a major supplier of process simulation software; West Virginia University; and Alstom Power, a major worldwide industrial player in equipment and services for power generation. The cooperative agreement assigned the commercialization rights to Fluent to ensure that the APECS software suite entered the market place as quickly as possible.



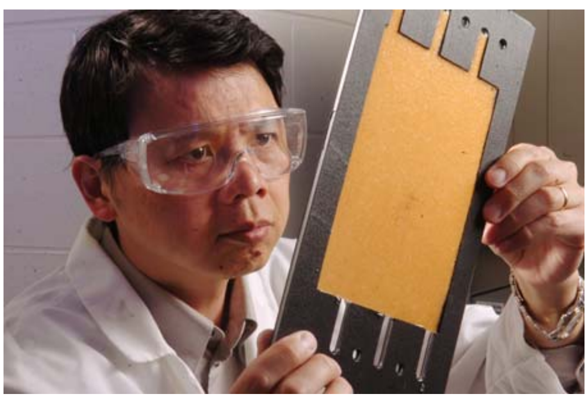
APECS helps to optimize overall plant performance with respect to complex thermal and fluid flow phenomena

Biorefinery Process for Making Ethanol

Argonne National Laboratory researchers are partnering with industry and other national laboratories to develop biorefineries that can compete economically with oil refineries. Argonne is one of five U.S. Department of Energy (DOE) laboratories working to replace today's motor fuel with alternative biofuels. Laboratory and industry researchers see developing alternative processes to replace the country's reliance on foreign oil as filling a national need. It is not just the price of gasoline that is affected however, as oil costs rise, so do all the costs of all petroleum-based products, including paint, plastics and carpets.

Argonne is working with Archer Daniels Midland Company (ADM) to optimize a separative bioreactor that converts sugar from corn into chemicals. *R&D* magazine named the technology one of this year's top R&D products. This research is supported jointly by the DOE's Biomass Program and ADM. The Argonne-ADM effort currently focuses on demonstrating the fermentation and separation of gluconic acid on a commercial scale. "Gluconic acid is one of many bioproducts from biomass," says Seth Snyder, a biochemical engineer at Argonne, "We have to work through the processes one by one to build up an inventory to compete with petrochemical processing. We chose to start with gluconic acid because we are familiar with its processes."

Gluconic acid is produced by fermenting glucose, a type of sugar. This reaction has been known for more than 100 years. The problem with this process is that during fermentation, gluconic acid builds up until its acidity blocks the fermentation enzyme. The acidity can be chemically neutralized, but the extra treatment raises costs and generates waste.



Argonne scientists are working to optimize a separative bioreactor that converts sugar from corn into chemicals.

In 2006, Argonne's separative bioreactor was successfully applied at the pilot scale, using a process called "electrodeionization" to overcome this acidification problem without the need for additional chemical treatments. Electrodeionization uses small amounts of electricity and Argonne's resin wafer stack to remove gluconic acid from the solution as it is produced. With the acidity kept lowremoved, the enzyme will continue to convert glucose to gluconic acid.

Body Scanner Shapes-up Security and Fashion

Pacific Northwest National Laboratory (PNNL) transferred its Millimeter Wave Holographic Body Scanner technology to the commercial sector. The two companies who have licensed the technology have done so for two very different markets—SafeView is using it for security screening, and Intellifit it using it for body measurement for the clothing industry.

This technology uses millimeter wave array/transceiver technology. The array/transceiver illuminates the human body standing within a cylinder unit or portal with extremely low-powered millimeter waves—a class of non-ionizing radiation not harmful to humans—that penetrates clothing and reflects off the body. The reflected signals are collected by the array/transceiver and sent to a high-speed image processing computer where they form a high-resolution 3D image of the body in less than 10 seconds. This holographic image can be used to identify anything hidden on the body—metal, plastic, ceramic, and other non-metallic items that could be used as weapons. The 3D image can also be used to calculate precise physical measurements.

SafeView, Inc., of Santa Clara, California, licensed the technology in 2002 to incorporate the holographic body scanning technique into its Scout™ Personnel Screening System. In 2006, SafeView was acquired by L-3 Communications, a Fortune 500 company offering products for security, aerospace, military intelligence, and telecommunications.

In 2003, Intellifit licensed the same technology for use in its kiosk designed to image customers for clothing fit. The Pennsylvania-based company worked with PNNL to develop sleek, portable cylindrical units that can scan body measurements of fully clothed clients in less than 10 seconds and give those clients an instantaneous list of their exact body measurements as well as recommendations for brands of clothing that will fit their bodies best. Intellifit has installed these units around the country in retail stores and malls.

Non-Intrusive millimeter waves penetrate clothing to reveal hidden objects of metal and plastic or to measure the human form.

The Millimeter Wave Holographic Body Scanner technology has been granted six patents and has received worldwide recognition, including a 2004 R&D 100 Award, the R&D magazine Editors' Choice Award for Most Promising New Technology in 2004, and a 2005 Federal Laboratory Consortium Award for excellence in technology transfer.

BROOM Speeds Clean Up

Building Restoration Operations Optimization Model (BROOM) is a software-based tool developed by Sandia National Laboratories for managing the collection, visualization, and analysis of environmental sampling data for first responders. BROOM improves the efficiency of clean-up operations, minimizes facility downtime, and provides a transparent basis for reopening a decontaminated facility. The last factor is critical in gaining public and regulatory acceptance for declaring a facility to be “clean” and safe to reoccupy.

BROOM comes from Sandia’s three-year joint development project, in collaboration with Lawrence Livermore National Laboratory which was sponsored by the Department of Homeland Security and includes partnerships with San Francisco Bay area airports.

Features provided by Broom include integrated data collection and fast and efficient data management. The easy-to-use visualization software provides the ability to manage information needed to help assess contamination within a facility, most effectively and efficiently plan operations to remediate that contamination, complete the clean up, and restore the facility to operation.

The centerpiece of BROOM is a handheld device, which resembles a typical PDA. The handheld device uses sophisticated algorithms to generate contamination maps and layouts of the location where responders are collecting samples. It also develops statistically based sampling plans; a barcode scanner to track tagged samples and maintain chain-of-custody records; and electronic forms to capture information such as the sample type, surface type and texture, collection method, and other important data that are collectively managed by the BROOM software.

During time-sensitive events when sampling data are needed quickly, information can be wirelessly transmitted to a PC or central command station outside a contaminated area. The results can be displayed on a map on both the handheld device and the PC, allowing decision makers to determine if an area is truly clean so that they can reopen facilities as quickly as possible.

Originally developed for use during clean up of facilities following a bioterrorism attack, BROOM is easily adapted to other spatial domains where accurate and efficient data tracking, management, optimization, and analysis of samples are needed. It has been tested extensively, including exercises in collaboration with the National Institute for Occupational Safety and Health, at Sandia’s Albuquerque site, and during a two-day demonstration event at San Francisco International Airport.

BROOM is used for accurate and efficient data tracking, management, optimization, and analysis of samples.

Cancer Treatment Technology

NorthStar Nuclear Medicine, Inc. and Idaho National Laboratory (INL) have signed two agreements on a major new technology to produce the extremely valuable medical isotope, actinium-225, for use in cancer research and treatment. The agreements will lead to expansion of the amount of medical isotope available for a new cancer radiation treatment that offers many advantages over traditional radiation treatment.

This patented invention --the Medical Actinium for Therapeutic Treatment (called MATT)--has been nominated for R&D Magazine's 2006 top 100 technologies. MATT is a novel process that separates actinium-225 from unused nuclear fuel. This technology is expected to increase the world production of the medical isotope, enabling important clinical cancer treatment trials to proceed. Actinium-225 can be used effectively in alpha-immunotherapy treatments, which combine an alpha particle-emitting radionuclide that is carried by a targeting agent such as monoclonal antibodies. The targeting agent seeks out and selectively attaches to cancer cells. The radioisotope then kills the targeted cancer cells, while minimizing collateral damage to surrounding normal cells. This treatment regimen offers many key advantages over external radiation exposure and chemotherapy.

A separations process recovers Actinium-225 from unused nuclear fuel that can increase the world production of the medical isotope, for cancer research and treatment.

The agreements between INL and NorthStar include a license for the company to use the MATT technology, and a cooperative research and development agreement (CRADA) supporting further development of the technology. Under the CRADA, NorthStar provides INL funding to develop MATT during the initial planning stage for designing and building a pilot plant to recover the medical isotope.

The Department of Energy is currently providing actinium-225 to researchers from its Oak Ridge National Laboratory in Tennessee. If INL and NorthStar are successful in further developing their technology, it would supplement this limited supply. In inventing this technology, INL researchers took advantage of the fact the INL has significant sources of actinium-225 in its 14 metric tons of 30-year-old unused nuclear fuel. This fuel was originally created to use in a breeder reactor, a research program that was discontinued in the early 1970s.

Carbon Explorer Monitors Ocean Carbon

Without a method for accurately observing daily changes in ocean life cycles over vast spatial scales, scientists are unable to predict how the ocean will respond to rising CO_2 levels, crippling our ability to develop accurate models of global warming or devise strategies to prevent it.

The Carbon Explorer, conceived by Lawrence Berkeley National Laboratory's James K. Bishop in collaboration with Scripps Institution of Oceanography and WET Labs, Inc., bridges this observational gap. The device is a smart, low-cost robotic ocean float that measures carbon concentrations in the ocean. With its system of optical sensors, advanced communications devices, and remote operating capacity, the Carbon Explorer enables, for the first time, the continuous tracking of the biological processes of the ocean's carbon cycle.

Until now, model simulations of the ocean carbon cycle, carried out using the world's fastest and most advanced computers, were the only known way to predict the future of the ocean's impact on climate change. The current generation of models includes biological processes, but only in a simplistic way. The observations guiding model predictions are largely based on data collected from ships, which cannot work safely in bad weather or in remote ocean locations for very long.

By contrast, Carbon Explorers have been deployed to date in some of the world's most remote and extreme ocean environments, consistently yielding data that had never before been generated. Once placed in the water by research vessel, small boat, or aircraft, the Carbon Explorer activates and locates itself in space using signals from Global Positioning System (GPS) satellites, and then begins a mission based on a set of preprogrammed instructions. The Carbon Explorer collects temperature, salinity, and particulate carbon data at various depths down to several kilometers and sends that data to satellites overhead. The device can stay in the ocean year-round to observe variations in the ocean carbon cycle. It measures particulate organic carbon at a level of accuracy, precision, and frequency previously unachieved, and it does so in real time.

The Carbon Explorer monitors carbon levels in the ocean (Photo courtesy Alexey Mishonov, Texas A&M University)

Carbon Explorers are being deployed from research vessels world-wide and those already deployed are continuously collecting and sending data. By providing the observational basis for accurate models of the carbon cycle and thus guiding human efforts to control the release of CO_2 into the atmosphere, the Carbon Explorer is making a critical contribution to DOE's mission of "discovering the solutions to power and *secure America's future*."

Detection Systems for Dirty Bombs

Anti-terrorism efforts are getting a boost from the Princeton Plasma Physics Laboratory (PPPL). A PPPL team has developed a Miniature Integrated Nuclear Detection System, called MINDS, which can be used to scan moving vehicles, luggage, cargo vessels, and the like for specific nuclear signatures associated with materials employed in radiological weapons. MINDS could be employed at workplace entrances, post offices, tollbooths, airports, commercial shipping ports, as well as in police cruisers, to detect the transportation of unauthorized nuclear materials.

A cost-effective compact system which combines many off-the-shelf components with specific nuclear detection software, MINDS is capable of detecting X-rays, soft gammas, gammas, and neutrons. Radionuclides can be recognized and differentiated from one another since each has a distinctive energy signature or fingerprint. The system compares the energy spectrum of the detected radionuclide with the spectra of particular radiological materials that might be used in weapons.

MINDS can detect one-billionth of the material deemed plausible to create a radiological dispersion device — a “dirty bomb.” The system can be deployed in a variety of applications, because it is capable of differentiating among naturally occurring radioactive elements, authorized medical and acceptable industrial nuclear substances, and threat materials. By identifying the specific radioactive material present, MINDS eliminates the “car alarm” syndrome, where the operator is accustomed to so many false alarms that future warnings could be ignored. MINDS can be configured to “filter out” natural radiation, or any acceptable radiation in the background environment. It is sophisticated to the degree that it will identify radioactive materials even when they are intentionally concealed or masked. As MINDS scans a target, in approximately one second the system senses, identifies, and transmits the presence of radioactive materials at levels slightly above background. Also, MINDS itself does not emit radiation and thus does not require active cooling as other technologies do. In addition, it can be fitted with up to three different radiation detectors, or heads, to cover a whole gamut of nuclear radiation. The detector heads can include, for example, a boron trifluoride or helium tube to detect neutrons; a PIN diode or a cadmium zinc telluride detector to detect X-rays and low-energy gamma rays; and a sodium iodide crystal to detect higher energy gamma rays.

MINDS deployed at a guard station

In March 2005 Princeton University signed a licensing agreement with InSitech, a not-for-profit organization that brings government-developed technology to market. MINDS is currently deployed at a U.S. military base, at a major rail and bus commuter center in the northeastern United States, and at a large company that provides security services to airports worldwide.

Drill String Radar Technology

Miners, oil companies, environmentalists, private businesses, the U.S. government, and Russian former weapons of mass destruction workers will all benefit from the new Drill String Radar (DSR) technology. An advanced geophysical exploration system, the DSR was engineered by Stolar Research Corporation as part of the National Nuclear Security Administration’s (NNSA) Global Initiatives for Proliferation Prevention (GIPP) program.

GIPP focuses on reducing the proliferation of weapons of mass destruction by redirecting the skills of former weapons workers to developing and manufacturing commercial, non-weapons products. Under GIPP, the NNSA’s National Laboratories and manufacturing facilities form partnerships with U.S. commercial industries and former weapons scientists in the former Soviet Union to evaluate opportunities for commercial projects.

The DSR was developed through a GIPP partnership between the NNSA’s Kansas City Plant; Stolar Research Corporation, a New Mexican radio geophysics engineering company; and scientists from the Measuring Systems Research Institute (NIIIS) in Nizhny Novgorod, Russia. Stolar saw the need for this technology, and recognized the GIPP program as an opportunity to realize their vision. The Kansas City Plant provided technical expertise to solve problems as they arose, and also served as project facilitator and manager between NIIIS and Stolar.

The new Drillstring Radar provides a radar navigation tool to determine the height of a coal seam, geologic conditions, and seam undulation without the need to drill to the roof and floor boundary rock. NIIIS is collaborating with Stolar to refine and commercialize the tool. Deemed one of most technologically significant products introduced into the marketplace over the past year, the Drillstring Radar received a 2005 R&D 100 award.

A few of the many benefits of Drill String Radar’s include reduced cost and more efficient mining by providing more accurate information about geologic structures; increased fuel production rates; enhanced recovery of oil and gas; increased safety for miners; and minimal surface disturbance which preserves the environment and prevents dangerous fractured roof rock.

The Drill String Radar technology provides many benefits for improved mining and oil extraction.

Drug for AIDS Therapy

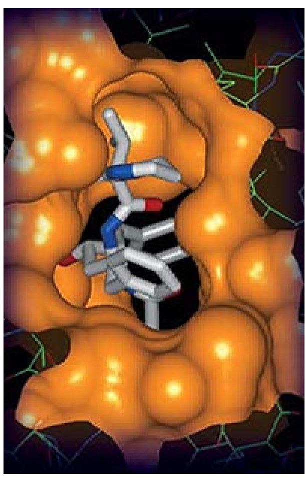
One of the early research projects undertaken at Argonne National Laboratory's Advanced Photon Source, was an examination of the Acquired Immune Deficiency Syndrome (AIDS) Human Immunodeficiency Virus, or HIV.

Designing an effective anti-HIV drug requires very precise design: the drug must be highly target-specific—in fact it must exactly fit the particular structure of the target molecule—the 'lock-and-key requirements' for drug designers. The design must also be flexible enough to accommodate changes in that structure.

Using X-ray crystallography, researchers found the points of attack of the HIV protease inhibitors – agents that block the breakdown of proteins. Protease inhibitors stop HIV from making new copies of itself by blocking the last step in the process, when the virus attempts to replicate. Out of that discovery came the drug Kaletra®, now the most-prescribed drug in its class for AIDS therapy and a product of Abbott Laboratories, which was one of the earliest users of the Advanced Photon Source.

Abbott Labs is part of the Industrial Macromolecular Crystallography Association (IMCA), which operates one of the beamlines at the Advanced Photon Source through a contract with the Center for Advanced Radiation Sources at The University of Chicago. Researchers took a close-up view of the protein called the HIV protease, revealing the atomic details of how compounds interact with the protein.

"Kaletra is a clear example of the positive impact derived from research at our DOE-sponsored facility," said Murray Gibson, Argonne associate laboratory director for scientific user facilities. "This premier national research facility provides the brightest X-ray beams in the Western Hemisphere to more than 5,000 scientists from around the United States and the world.



The drug Kaletra®, now the most-prescribed drug in its class for AIDS therapy

Abbott researchers began clinical trials with Kaletra in the late 1990s and the longest clinical study of any HIV treatment – seven years – ended in late 2005 with data demonstrating that patients taking Kaletra in combination with other antiretroviral agents maintained an undetectable viral load (amount of virus in the blood) of less than 50 copies per milliliter, as measured by HIV RNA. It is commonly remarked that Kaletra is a drug that helped turn a situation where patients were dying from AIDS to a situation where they are living with AIDS.

Electron Beam Welding

Lawrence Livermore National Laboratory (LLNL) is partnering with Sciaky, Inc., of Chicago, Illinois, to develop and commercialize its electron beam diagnostic tool. The E-beam diagnostic, originally developed for internal use by the DOE complex, will be commercialized in partnership with Sciaky, Inc. The new product, EBeam 20/20 Profiler will be integrated into Sciaky's new generation of welder. The diagnostic tool was designed to be used in any conventional electron beam welding machine without modifying the welder. Its hardware is compact, weighing less than 2.5 lbs, and has no moving parts.

In the past, creation of consistent beams was essentially an art that depended on the experience of the welder operator. The LLNL diagnostic opens new avenues for designing improved electron beam welding guns, and understanding the interactions of electron beams and various materials. Data from the profiler can be fed into computer models to generate the most accurate simulations yet of electron beam welds.

The diagnostic tool consists of enhanced modified Faraday cup and computer tomography software, which offer the first rapid means of analyzing intense electron beams. Such beams are frequently used in high-value welds in the nuclear and aerospace manufacturing sectors. The tool provides data on the beam's focus and power density distribution in real time. With this essential quality control information, electron beams can be precisely reproduced on the same machine over a period of time, and these parameters can be precisely transferred to other welding machines.

E-beam diagnostic will be integrated into a conventional electron beam welding machine

The LLNL diagnostic allows the user to quantify the power density distribution; determine the sharp focus of the electron beam; and correlate weld machine settings with beam properties and ultimately the welds themselves. All of the capabilities enhance a critical need for quality assurance in high value welds.

The new partnership between Sciaky and LLNL is intended to develop the EBeam 20/20 Profiler, a commercially available tool which Sciaky intends to integrate its next generation of automated welding units. . The partnership will focus on increasing the robustness of the hardware to withstand the operating conditions of industrial welders.

Enzymes for Producing Biofuels

A new genus and species discovered by National Renewable Energy Laboratory (NREL) scientists has the potential for widespread use in the biomass industry. The biomass industry is aimed at changing the way that many industrial chemicals are produced today through the promotion of the "biorefinery" concept. A biorefinery is a facility that integrates processes and equipment to produce fuels, power, and chemicals from organic materials, such as corn or wheat. The biorefinery concept is analogous to today's petroleum refineries, which produce multiple fuels and products from petroleum.

NREL packaged this discovery into a enzyme technology that has the potential to improve productivity for the biorefinery. This technology, E1 Thermostable Endoglucanase (E1), allows manufacturers to create industrial chemicals at a greatly reduced temperature, as well as at a greatly accelerated process, which translates into cost savings for the biomass industry. This platform technology is designed to utilize a renewable technology based on enzymes to convert organic materials into sugars, for further development of ethanol/fuel, as well as other chemicals, and products.

In the early 1990s there was speculation regarding the patentability of biological compositions of matter including discoveries such as NREL’s E1. NREL took on the challenge and worked closely with the U.S. Patent Office Examiners to demonstrate that cellulase enzymes displaying thermal tolerance and hyper activity were indeed patentable. NREL then secured the four patents that comprise its E1 technology.

The primary use for enzyme technology worldwide is for the active biological component of detergents and cleaning products. Enzymes are also used in the textile industry, mainly in the manufacturing of fabrics and garments. Enzymes are also used in the areas of recycling/reprocessing operations for cellulosic materials, as well as food and animal feed, pulp and paper, brewing, and grain feedstock processing. The worldwide market value for this new enzyme technology is estimated to be $500 million and growing.

NREL secured a license agreement with Genencor International (Genencor) for the E1 suite of patents. NREL teamed with Genencor because they hold already many patents and applications worldwide and have demonstrated results in successful biotechnology commercial applications. This new license agreement between NREL and Genencor is an opportunity for the biotechnology industry to begin production from plants and other renewable resources, which promote both environmental and industrial sustainability in addition to being cost competitive with, or even less expensive than those synthesized through traditional chemistry.

A new enzyme will allow biorefineries to create industrial chemicals at a greatly reduced temperature, as well as at a greatly accelerated process.

Fiber Optic Sensor for a Hydrogen Economy

The National Renewable Energy Laboratory (NREL) has entered into a CRADA to develop and commercialize NREL's innovative fiber optic hydrogen sensor technology with Nuclear Filter Technology. In addition to the CRADA, Nuclear Filter is licensing several NREL inventions related to fiber optic and thin film materials that sense the presence of hydrogen gas.

NREL's fiber optic hydrogen sensor utilizes a non-ignitable, flexible, thin, glass or plastic, fiber optic strand that transmits light to a thin film material that changes color in response to the presence of hydrogen. Many industries rely on the ability to quickly, easily and reliably sense the presence of hydrogen because of the naturally explosive and dangerous nature of hydrogen. Very much like natural gas, it only takes a small amount of hydrogen in the air and a small spark, such as turning on a light switch, to cause it to ignite and explode. So therefore, early detection of hydrogen through NREL's fiber optic hydrogen sensor is essential to safely handling hydrogen, and ultimately supports the market viability of a hydrogen-based economy.

This technology has applications in industries that use or produce hydrogen including, petrochemical, transportation, fuel cell applications, fuel production, food processing, natural gas, and nuclear waste. These inventions offer advantages over existing technologies in many applications, but have been demonstrated only at a bench scale. This CRADA is allowing NREL to collaborate with Nuclear Filter Technologies to develop a full-scale prototype and ultimately commercially available products.

The hydrogen sensing market is a strong market with potential growth because of a policy market driver to develop a hydrogen-based economy. The development of a hydrogen-based economy is a strategic initiative set forth by the White House and the Advanced Energy Initiative. Currently the size of the hydrogen market is $800 million, and is estimated to grow to $1.6 billion by 2010.

NREL's fiber optic hydrogen sensor is essential to safely handling hydrogen.

Ultimately, this technology transfer effort will allow NREL and Nuclear Filter to further develop fiber optic hydrogen sensors to deliver commercially available solutions for nuclear waste packages, automobiles, industrial plants and anywhere else hydrogen may be present. This transfer provides a safer solution for the hydrogen industry, and is cost effective to implement. The inherently safe quality and cost effectiveness of this technology will also help secure Nuclear Filter's position within the market, and has the opportunity to foster economic growth within the hydrogen industry.

Fuel Cell Advances

Los Alamos National Laboratory (LANL), was selected by 3M for evaluation of its early work in fuel cells based on its 20 years of experience in this area. The 3M fuel cell effort began with a novel, 3M proprietary, nanostructured thin film (NSTF) catalyst system for use in proton exchange membrane (PEM) fuel cells. LANL evaluated the first set of membrane electrode assembly (MEA) samples fabricated by 3M with NSTF catalysts in March 1995. This led to a two-year CRADA between 3M and LANL for testing 3M NSTF catalyst electrodes in LANL-developed MEAs, which were put into LANL's PEM fuel cells and evaluated as possible direct methanol fuel cells (DMFC). This CRADA was performed in conjunction with the Defense Advanced Research Projects Agency -sponsored DMFC program for military portable power applications.

Using a variety of 3M technologies, 3M established a fuel cell commercialization program, including PEMs, dispersed catalyst electrodes, and gas diffusion electrode backing layers, and became a leading supplier of 5-layer MEAs for PEM fuel cells. Concurrently, 3M partnered with DOE in five cost-sharing CRADA projects with Los Alamos, Lawrence Berkeley, Brookhaven, and Argonne National Laboratories, and collaborated with six universities and four systems manufacturers under what is now the DOE Hydrogen, Fuel Cells, and Infrastructure Technologies Program.

These projects have focused on issues that must be addressed for PEM fuel cells to be commercially viable for automotive and distributed stationary applications including performance (efficiency and peak power), durability, and cost. Under these projects, DOE goals for the year 2010 for fuel cells in automotive applications have been met in the areas of precious group metal loading and cost, with significant progress made toward the 2010 fuel cell MEA durability goal. Laboratory results have been verified in fuel cell stack testing by 3M and systems manufacturers. The feasibility of high volume MEA and component fabrication processes has been demonstrated and the fundamental understanding of factors affecting performance and lifetime has increased.

Direct methanol fuel cell stacks using advanced membrane technology.

Grids and Collimators Produce Better X-ray and Nuclear Images

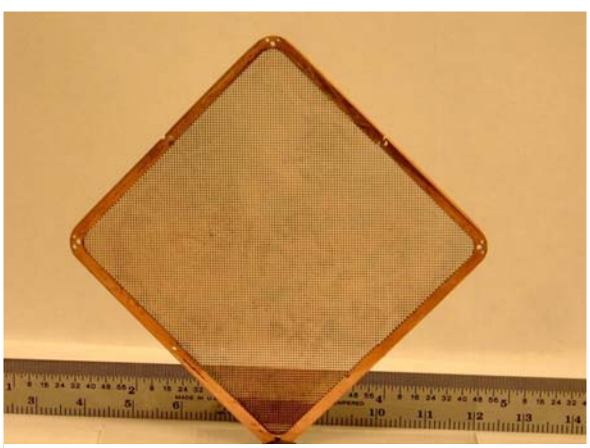
A grid as little as three millimeters tall could save lives by helping X-rays and radiotracers provide clearer diagnostic images of the human body. These X-ray anti-scatter grids and nuclear collimators were developed by scientists at Argonne National Laboratory and Creatv MicroTech, Inc. “The two areas where it's important for medical imaging are mammography and gamma ray imaging,” said developer Derrick Mancini of Argonne's Center for Nanoscale Materials. “Both of them are critically important for early detection of cancer and other diseases. The impact, therefore, is saving lives.”

X-rays, create an image based on the density of the matter. However, before a beam of X-rays hits the target, the X-rays are attenuated and scattered. Scattered X-rays modify and cloud the image, which can lead to medical misdiagnoses. Anti-scatter grids are placed between the target and the imager to greatly reduce or eliminate this X-ray scattering.

"The basic concept of an anti-scatter grid is not new," said Cha-Mei Tang, president of Creatv MicroTech, "but our method can make two-dimensional grids that reduce scatter to less than one percent. This is far more effective than one-dimensional grids currently on the market, which reduce scattering to about 10 percent."

The anti-scatter grids developed by Argonne and Creatv MicroTech, however, are superior to existing anti-scatter grids because they are made using a method called LIGA, a German acronym that refers to lithography, electroforming and molding.

Argonne's Advanced Photon Source (APS) is normally used to analyze materials. The LIGA produced anti-scattering grid is the first time that the APS was used in the fabrication of an industrial product. Grids produced in 2006 were shown to be highly effective in improving X-ray images. To make an anti-scatter X-ray grid in the LIGA method X-rays from the APS burn a deep grid pattern into a thick polymer. After placing the exposed polymer in a developer, the polymer mold for the grid pattern is obtained. The grid mold is filled with metal by electroplating, and when the polymer is removed, a grid results.



X-ray anti-scatter grids and nuclear collimators can help save lives

While many previous anti-scatter grids were one-dimensional, the LIGA grids consist of two-dimensional cells. These cells are divided by walls as thin as 25 microns (millionths of a meter), a thinness that cannot be achieved with other methods for making anti-scatter grids, such as casting, foil folding and chemical etching. For one-dimensional grids, the measured transmission of primary X-rays is 72 percent. A competing cellular grid transmits 80 percent, but the LIGA grid transmits the highest proportion of primary X-rays: 87 percent.

High-sensitivity and Low-cost Infrared Camera Detectors

Battelle Ventures has invested in Oak Ridge National Laboratory's (ORNL) licensee Multispectral Imaging, Inc. (MII). MII's mission is to build high-sensitivity, low-cost infrared camera detectors that enable soldiers and firefighters to "see" objects at night or in smoky areas. The detector will incorporate ORNL's infrared-sensing microcantilever array technology into MII's capacitive sensing readout chip.In the MII version of ORNL's array, 160 × 120 silicon microcantilevers, each 50-micron-long microcantilever, which represents a pixel, bends in proportion to the intensity of the infrared radiation striking it. Every object gives off infrared light; the hotter the object, the greater the number of infrared photons emitted. Competing infrared sensing technologies can be either cooled to cryogenic temperatures or operated at near room temperatures. The "un-cooled" ORNL microcantilever technology operates at room temperature, and because this technology requires no cooling, it uses less energy than most competitors, lowering the cost. MII's capacitively sensed microcantilever array offers high resolution, low noise and impressive dynamic range, allowing users of the future camera to take finely detailed pictures of objects with high sensitivity in both brightly lit and dark, smoky rooms.

ORNL's Infrared-sensing
Microcantilever Array Technology

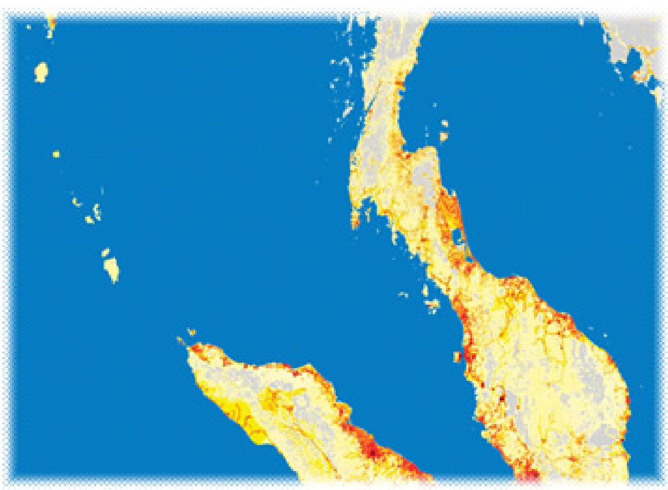
MII first licensed ORNL's microcantilever technology and then licensed two related inventions. Later the company entered a work-for-others agreement with ORNL to get help in characterizing the sensitivity of MII's test devices and measuring how much a cantilever bends with changes in infrared light intensity.

In just one year, the MII engineering team made arrays of uniformly released microcantilever sensor structures that have up to five times the responsivity of the previous licensee's devices. The microcantilevers bend out of the sensor plane, avoiding sticking problems that were previously encountered. MII redesigned and fabricated the electronics to eliminate readout problems that caused low sensitivity.

LandScan Population Distribution Database

After the Indian Ocean tsunami of December 2004, Oak Ridge National Laboratory's (ORNL) LandScan "High Resolution Global Population Data Set" was used extensively in emergency response. ORNL's award-winning population distribution database helped government agencies estimate how many people were potentially affected and where to send emergency supplies. LandScan, which refines the best available census data using geographic information system and remote sensing technologies, has emerged as an international community standard for disaster response, humanitarian relief, sustainable development and environmental protection. Today, LandScan is one of the most licensed of all ORNL technologies.

Also on the rise is the number of commercial, revenue-generating licenses of LandScan. High-profile users include *National Geographic*, *TIME* magazine, the *Washington Post*, and *New York Times*. In FY2005, UT-Battelle granted 123 non-commercial LandScan licenses to the United Nations, government agencies and universities worldwide for humanitarian, research and educational purposes. In 2006, the number rose to more than 250 non-fee-bearing licenses. Research using LandScan has also resulted in numerous publications on subjects of interest to policy decision makers such as predicted effects of global climate change.



Data from the LandScan 2004 Global Data Set indicate detailed distribution of population in Indonesian areas affected by the December 2004 tsunami. The population density is highest in orange and red areas of map.

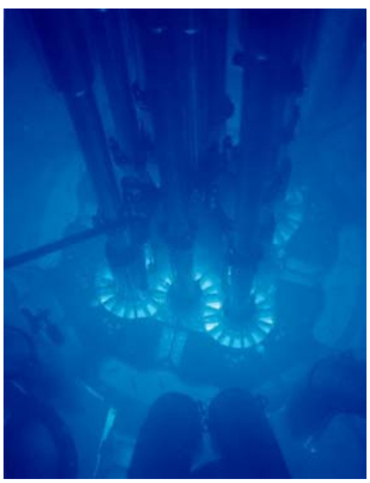
Medical Isotope Testing

Five organizations gathered to announce the signing of collaboration and partnership agreements for testing production of a breakthrough medical isotope at Idaho National Laboratory (INL) in 2006. The Advanced Test Reactor (ATR) is a unique facility that offers expanded isotope production capabilities in the U.S. and tests fuels and materials for future reactor design efforts such as Generation IV reactor development.

"The ATR is one of the world's most versatile and best-designed test reactors, which has a long successful history of operation that continues today with attention to safety, maintenance and important upgrades," said INL Laboratory Director John Grossenbacher. "Producing medical isotopes is a key mission for ATR and it is a major contribution by one of Idaho's most valuable assets."

The development program would enhance IsoRay Medical company's production capabilities of its proprietary brachytherapy seeds containing the medical isotope, cesium-131. The company received Food & Drug Administration approval to market its cesium-131 seed for the treatment of prostate cancer and other malignant tumors in 2003. IsoRay Medical is the world's only manufacturer and distributor of brachytherapy seeds containing the cesium-131 isotope. IsoRay's test will be conducted in the ATR during 2006. The overall program will involve design, analysis and fabrication of a capsule that will contain barium carbonate, which will be irradiated during the test and then shipped to IsoRay for final analysis.

The cesium-131 isotope is currently being used in brachytherapy treatment for prostate cancer, which is the second leading cause of cancer deaths among men in the U.S. Protocols are currently scheduled to begin during the first quarter of 2006 for both the lung and the pancreas. Other forms of delivery devices for the isotope are also being considered, which may create a higher demand for the isotope.



INL Advanced Test Reactor used in testing medical isotopes

ATR has conducted valuable medical research and produced important industrial isotopes. These efforts have provided isotopes like Cobalt-60 for treatment of inoperable vascular deformities and brain tumors, and Iridium-192 for radiography research, along with other materials.

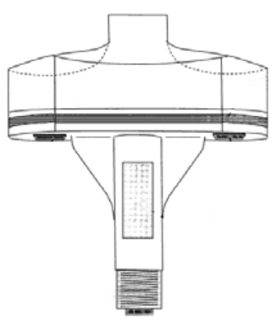
MEMs Sensor Technology for Orthopedic Implants

Advances in surgical techniques and materials have enabled widespread use of complete joint replacements for knees and hips. Though improving, friction surfaces in all orthopedic implants experience load-dependent wear that ultimately limits their useful lifetime. Replacement of a worn artificial joint, though possible, is generally avoided due to the need for additional surgery. Because of this, joint replacements are often delayed so that the life expectancy of the recipient and the artificial joint are approximately correlated.

Researchers at Oak Ridge National Laboratory (ORNL) and the University of Tennessee have developed a patented approach for implanting MEMs (micro-electro-mechanical systems) sensors for monitoring orthopedic implants. The invention is a technique enabling accurate measurement of direct wear and force parameters that can be incorporated into both research and clinical implants for continuous or periodic wear and load assessment. In addition, the invention can incorporate different sensor types allowing monitoring of surrounding physiological parameters including tissue encapsulation, bone condition, osteo-integration status including implant loosening, and the presence of infection. The invention is suitable for use with many different implant types including artificial knee, hip, shoulder, and elbow joints, and may find use in spinal or other applications where bone is involved.

The invention has recently been licensed to Zimmer, Inc of Warsaw, Indiana, a worldwide leader in joint replacement solutions for knee pain and hip pain. The company also provides a broad range of trauma, dental implant, and orthopedic surgical products. Founded in 1927, Zimmer is committed to providing effective techniques in hip replacement and knee replacement for orthopedic surgeons who restore mobility and relieve the pain of osteoarthritis and traumatic injuries with valuable partners in more than 80 countries.

Zimmer has embarked on a 10-year plan to develop, test and introduce artificial joints and other products incorporating this patented technology.



MEMs sensor placed
on orthopedic implant.

Multiport Dryer Paper Design Will Improve Paper Drying Process

Cheaper and more energy-efficient paper production could result from an innovation developed at Argonne National Laboratory. The design of a Multiport dryer technology was completed in 2006 and shown to improve the process of paper drying and saving energy in the final step in paper production.

In the current process, paper is dried by passing it over 30 to 100 large-diameter, steam-heated cylinders. This process requires a significant amount of energy. Argonne's Multiport dryer has a series of longitudinally oriented passages, or "ports," near the inner surface of the drying cylinders. Basically it is a metal cylinder with long, thin channels indented in the sides from top to bottom. This cylinder fits closely inside the outer drying cylinder, forming tubes that carry steam against the dryer cylinder's surface. This multiport flow configuration increases the rate of heat transfer, drying the paper faster and more efficiently.

"Argonne's Multiport dryer may become one of these major innovations in drying," said mechanical engineer Stephen Choi. The invention is now in final prototype development and testing. It is being designed so that it may be installed in existing dryer cylinders. Exact details of the cost are still being determined, but the likely price for the retrofit will be under $10,000, which is less than 20 percent of the installed cost of a new dryer. Gains in paper production rate of 20% to 50% were realized in test runs last year.

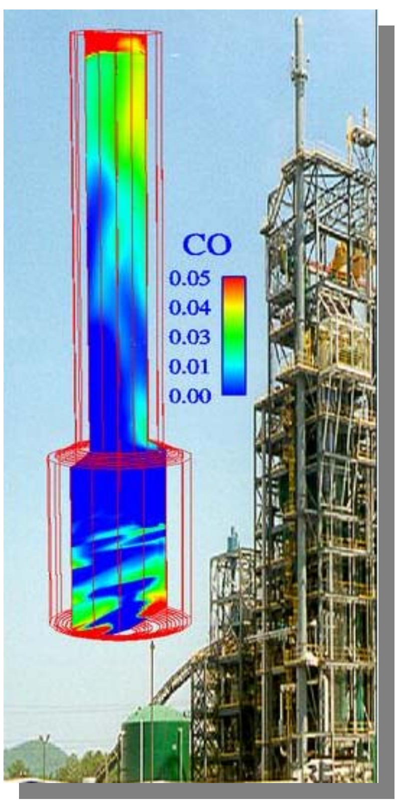
Multiport dryer design technology will improve the process of paper drying and save energy

In 2005 and 2006, David France of the University of Illinois at Chicago produced excellent results with Multiport dryer heat transfer test apparatus. Kadant Johnson, one of the leading equipment suppliers in the paper production industry, gave the Multiport dryer team a practical guide to the development of Multiport dryer technology. Choi said the company is "ideally set up to be a partner in the important bridging stage to commercialization."

Open-Source Software for Power Generation

Researchers at the Department of Energy's (DOE) National Energy Technology Laboratory (NETL) developed the MFIX (Multiphase Flow with Interphase eXchanges) software as a physics-based model of multiphase reactors to solve scale-up problems for advanced power plants. Advanced power plant technologies require *multiphase* reactors for processing fossil fuels; for example, coal (*solids-phase*) is reacted with steam and air (*gas-phase*) in a gasifier. The scale up of such multiphase reactors is notoriously difficult; engineers cannot reliably predict commercial-scale (large) reactor performance merely based on pilot-scale (small) reactor performance. NETL's effort has resulted in the development of MFIX, which is being transferred through the open-source method (www.mfix.org) and collaborative projects with end users.

MFIX simulates heavily-loaded gas-solids flows, commonly encountered in fossil fuel processes and in other industries such as chemical, petrochemical, pharmaceutical, and mineral. MFIX calculates the detailed motion of gas and solids in a general process vessel, allowing for the effects of heat transfer and chemical reactions. In 2001, MFIX was declared open-source software, a novel technology transfer mode increasingly being used by software developers. This has allowed the flow of this technology to universities, national laboratories and industry as well as enabled a reverse flow of technology into MFIX from external researchers. Now there are around 1000 registered MFIX users from over 250 institutions worldwide. The software is being used by a number of universities to advance multiphase science, which has resulted in numerous publications and 15 graduate theses over the last five years.



MFIX simulation of pilot scale KBR/Southern transport

A collaborative project between NETL and gasifier developers has resulted in MFIX being used for advanced gasifier design. For the last three years NETL researchers have been using MFIX to simulate the transport gasifier at the Power Systems Development Facility, Wilsonville, Alabama. The simulations convincingly showed the gasifier developers that the model does not merely reproduce what is already known, but provides insight into unobserved phenomena, which they could later experimentally verify. Also MFIX was used to predict the expected gasifier behavior almost a year before certain design modifications were completed.

The open-source distribution has led to non-fossil fuel applications as well. For example, Los Alamos National Laboratory is using MFIX to explore multiphase dynamics (e.g., dust explosions) in the Yucca Mountain Project, Nevada, the proposed site for the United States' first permanent geologic repository for high-level radioactive waste.

Pocket-Sized Card Detects Explosives

Developed by the Lawrence Livermore National Laboratory and licensed to Field Forensics, Inc. in 2006, the Easy Livermore Inspection Test Explosives (E.L.I.T.E. ™), is a detection tool that can quickly and accurately locate small amounts of explosives. It is easy to use, small enough to carry in a shirt pocket, and requires minimal training for deployment. Designed for use by emergency response, law enforcement, and military personnel, E.L.I.T.E. cards are particularly useful for screening vehicles, containers, and people for explosives residue. The 5- by 7.5-centimer card weighs a fraction of an ounce. Due to the simplicity of design, test results are almost immediate. After a card has been used, it can be discarded in a trash container without special handling.

To collect a sample, a user removes the swipe from the card, rubs it on a suspect area–a shoe, car door, or suitcase–and slides it back into the card. The user then ruptures two sealed ampoules that contain the developing chemicals. Within a minute, an explosive trace, if present, will be highlighted as a brightly colored spot on the white swipe. Explosives generally show up as bright red or bright pink, so they are easy to distinguish from direct and other stray substances. The chemical formulation used in E.L.I.T.E. cards can detect military and commercial explosives, such as C-4, Semtex, TNT, and derivatives, as well as inorganic explosives and propellants, such as ammonium nitrate and black powder.

E.L.I.T.E. cards are inexpensive over their lifecycle relative to other commercially available screening systems. Similar screening products have an average shelf life of one year or less. E.L.I.T.E. reagents have an indefinite shelf life and do not have to be replaced. The E.L.I.T.E. card also has lower detection limits than other similar types of screening products and can detect more than 30 types of explosives and propellants. In addition, reagents are self-contained in each card, so users are never exposed to these chemicals.

In 2006, the E.L.I.T.E. technology won an R&D 100 Award from *R&D Magazine* as one of the 100 most technologically significant products introduced into the marketplace that year; and also an Award for Excellence in Technology Transfer from the Federal Laboratory Consortium for the outstanding work in the process of transferring a technology developed by a federal laboratory to the commercial marketplace.

Successive generation designs leading from the first prototype to the current configuration

The current commercially available card produced by Field Forencisc, Inc.

Removing Metal Contaminants from Materials

Pacific Northwest National Laboratory (PNNL) has developed an innovative technology that quickly and easily reduces or removes mercury without creating hazardous waste or by-products, and that can be disposed of as a non-hazardous waste.

SAMMS™ (Self-Assembled Monolayers on Mesoporous Supports) is simple, inexpensive and easy to use; it is highly adaptable for use in reducing and removing metal contaminants from aqueous and non-aqueous materials; and it has numerous applications, including water treatment, waste stabilization, and metal processing and finishing. It is also significantly faster, more effective, and far less expensive than other mercury removal methods.

The SAMMS technology was first licensed to Steward Environmental Solutions, LLC, a manufacturer of advanced powders and nanomaterials. Steward signed its first licensing agreement in 2005, intending to initially market SAMMS for treating gaseous emissions such as those that come from coal-fired power plants, municipal incinerators, and other similar plants where testing has begun.

In March 2006, Steward signed a second license agreement for the manufacture and sale of SAMMS for multiple fields of use. PNNL continues to refine and test new applications that will broaden the range of contaminants effectively treated by SAMMS. The company hopes to work with PNNL on the production of these applications; Steward plans to produce SAMMS on an industrial scale.

SAMMS is a simple, inexpensive and easy-to-use technology that absorbs mercury in liquids and can be easily disposed of afterwards.

Additional technology transfer activities for SAMMS have engaged Perry Equipment Company (to remove mercury from "produced water" resulting from off-shore drilling) and Chevron (formerly Unocal, to remove mercury from crude oil).

The technology continues to garner international recognition, including features in numerous high-profile scientific, technical and trade publications, and nods from the scientific community including a 2006 R&D 100 award and recognition as a finalist in the environmental category in *Discover* magazine's annual awards for technological innovation.

Separating Organic Material into Value-Added Chemicals

A team of National Renewable Energy Laboratory's (NREL) researchers has created an innovative technology and process designed to effectively separate organic materials such as corn, wheat, oat hulls, and waste from cotton, and other lignocellulosic material, into pure streams of value-added chemicals such as lignin, cellulose and dissolved sugars (hemicellulose). These pure streams can be used to produce chemical products for a variety of industries such as pulp and paper, chemical, food, and packaging. Additional value is generated in that a variety of organic, clean (no net greenhouse gas) material feedstocks can be used.

This new technology incorporates an innovative strategy that overcomes previously difficult and costly chemical separation processes. NREL's new method enables a variety of organic materials to be separated by a highly efficient, single-phase process that produces very pure chemical products such as, cellulose, hemicellulose, and lignin products. These separated materials can then be efficiently fermented to produce a variety of consumer products such as fuel ethanol, food additives, chemical building blocks, cement additives, and adhesives to name a few. The NREL technology and process adds value on several levels such as allowing the manufacturer flexibility in the feedstocks they use to the products they produce to the revenue streams created from the products.

Key markets for this technology include the biomass to ethanol industry as well as other applications including the production of a pure stream of cellulose, which can be converted into other products for the paper and pulp industry, chemical industry (breakdown the cellulose into sugars which can be transformed into value added products), and the packaging industry. The lignin can be used in cement additives, as well as adhesives. The hemicellulose fraction can be converted into sugars such as the sweetener xylitol. The market value for this technology is already at the multi-billion dollar mark and has the potential to continue to grow.

NREL's technology can effectively separate organic materials into pure streams of value-added chemicals

NREL has secured a worldwide exclusive technology license between UTEK and Xethanol Corporation. NREL is very enthusiastic about this new licensing deal and is collaborating with Xethanol Corporation, as they develop and commercialize this new technology.

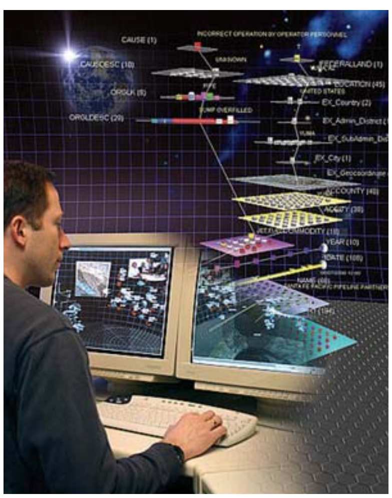
Xethanol Corporation seeks to become a leader in the emerging biomass-to-alcohol industry. Their mission is to convert biomass that is currently being abandoned or land filled into ethanol and other valuable co-products.

Starlight Information Visualization System

Pacific Northwest National Laboratory (PNNL) has developed a software solution to quickly visualize common themes in large disparate data. Starlight Information Visualization System has enabled nearly 40 entities to access and interpret information about business intelligence, consumer trends, medical records, current events, and cyber security data; and to enhance their operations by exploiting the data to their competitive advantage. Some companies report saving millions of dollars in the process. These companies use Starlight to extract consumer and product information pertinent to their business operations from enormous masses of data that previously were virtually inscrutable.

Starlight performs high-speed, high-efficiency analysis, and displays the results graphically so that the relationships among the data and their implications can be quickly and easily understood. While other commercial software products support only a few predefined data types, Starlight supports the concurrent analysis of an unlimited variety of information types. Furthermore, the software combines multiple visualization techniques allowing many different aspects of large information collections to be analyzed simultaneously. With this built-in flexibility, Starlight offers insight into and the ability to address a wide range of problems that previously was difficult or impossible to interpret.

Starlight was developed originally for intelligence analysis applications, and its national security uses continue to expand. But the astute and innovative researchers who developed Starlight recognized that its capabilities were germane to many enterprises in the commercial marketplace and directed efforts to successful technology transfer.



Starlight expedites knowledge discovery and strategic decision-making that could lead to advances in scientific discovery, energy distribution, remote sensing and many other areas.

Between 2000 and 2005, nearly 40 licenses were issued to organizations ranging from government offices to academia, from small competitive intelligence companies to large organizations, including Proctor and Gamble, a major automotive manufacturer, the Ohio State University, University of Delaware, Oregon Health Sciences University, Synaptics, the government intelligence community, the Veterans Administration, and the Joint Warfare Analysis Center. These customers consistently report that Starlight provides a higher level of visualization analytics capability than any other product on the market today.

Strategic Alliance for Advanced Energy Technologies

The Chevron Energy Technology Company, the part of Chevron responsible for developing and fielding advanced new technologies across the corporation, maintains a network of partnerships to identify new technology opportunities. Chevron anticipates that the following Los Alamos National Laboratory (LANL) technologies will be further developed, demonstrated, and deployed to the entire energy industry under its Alliance with LANL.

LANL's INFICOMM technology enables wireless communication in working oil and gas wells to allow data transmission rates up to a million times faster than conventional techniques so that real-time, broadband production data can be obtained spearheaded the Alliance. For the oil industry, methods to communicate down the well have generally been unreliable. Conditions are corrosive and the extreme pressure and high temperatures challenge conventional electronics. The INFICOMM system would also allow production data to be sent from remote wells to a platform without using batteries or other power.

LANL's Swept Frequency Acoustic Interferometry (SFAI) technology is being used for acoustic sensing and characterization in applications related to fluid flow through a pipeline ranging from determining various factors involved in fluid quality (oil, mud, etc.) and the interaction of the fluid with the pipeline (e.g., depositions) to determining the condition of the pipeline itself. SFAI will enable continuous well-performance measurements and determination of fluid properties as well as composition without the need for physical samples or intruding on the flow stream.

LANL's Trapped Annular Pressure (TAP) technology has the potential to save every deep-sea oil well from catastrophic failure resulting in a savings of hundreds of millions of dollars to the oil industry. Deepwater drilling fluids trapped in the annulus around well casings expand in response to high temperatures when wells begin producing. This in turn causes extremely high pressures that can rupture the well casing, destroying a well that may be 30,000 feet deep. TAP solution uses a monomer liquid that combines to form a solid polymer upon exposure to heat. When the monomers are present in drilling fluid, they cause a reduction in volume that eliminates the pressure build up.

Chevron Energy Technology Company is responsible for making technology available to Chevron's operating companies under this Alliance business model in which it works with oil and gas suppliers to develop, demonstrate, and deploy new technologies and products.

The drill ship Discoverer Deep Seas used LANL technology to drill Tonga, the deepest well ever drilled in the U.S. Gulf of Mexico. Photo courtesy of Chevron

Thermo Electron Partnership Protects America's Ports

The entry of fissile material in the form of a dirty bomb or nuclear weapon through America's ports continues to be a major threat to the nation. In this dangerous environment, Sandia National Laboratories is providing innovative systems that enhance the probability of detection. Sandia recently concluded a CRADA with Thermo Electron Corporation that licensed the Sandia-developed FitToDB algorithm for commercial use in a spectroscopic portal to identify concealed nuclear devices. As a result of the capabilities transferred by the licensing agreement, interest in the Thermo Electron spectroscopic portals has been shown by the Department of Homeland Security, the Defense Threat Reduction Agency, and the Border Patrol and Customs.

Sandia's unique capabilities in monitoring for nuclear materials have been honed by its work on the SMART system, which detects radioactive materials passing within a few meters of the detector. The SMART system, funded by DOE, consists of commercial hardware (gamma-ray and neutron detectors) combined with customized electronics and software developed at Sandia. FitToDB is the copyrighted software for isotope identification used within the SMART system.

Thermo Electron combined the Sandia algorithms with its existing algorithms to create a value-added platform, based on proprietary Thermo Electron architecture. The ThermoXChannel architecture, combined with Sandia intellectual property, yielded the ultimate system for detecting and unambiguously identifying radionuclides in motion. This revolutionary new approach to detecting and identifying isotopes may also, in the future, allow several detectors (rad/nuc, chem, bio, etc.) to be supported off single-board architecture, yielding simplicity and total integration of multi-analyte detectors. The ultimate goal is to be able to monitor 10,000 containers a day at a location with a vehicle traveling 3 mph.

Thermo Electron has used the FitToDB algorithm and sensor design principles imparted during the technology transfer process to construct several sensors that have been delivered to various sponsors. Sensors that will be used for domestic applications include several ARIS (Advanced Radionuclide Identification System) portals that were delivered to the Defense Threat Reduction Agency and two Advanced Spectroscopic Portals (ASPs) delivered to the Domestic Nuclear Detection Office. Thermo Electron also developed portals for use under the Megaports program. These sensors (ARIS-2) include a stationary installation and a mobile system.

This innovative partnership has transitioned DOE-funded technology vital for national security from Sandia to a commercial provider of a unit that is highly reliable and extremely sensitive in detecting nuclear material.

A SMART cart scanning a truck for nuclear materials

Tire Pressure Sensing Technology

Measuring the pressure and other parameters of tires at operating speeds is necessary for a new generation of safe, efficient tires supported by developing technologies. As the world's largest tire manufacturer and the only American tire manufacturer, Goodyear Tire and Rubber Company wondered if it would be possible to mount wireless, robust transient sensors in its tires to monitor tire pressure and other parameters. While current technologies allowed tire pressure to be monitored, these systems used individual batteries, required considerable maintenance, and were also fairly expensive. Goodyear had a better idea, but it needed help from Sandia National Laboratories, which had the background in sensor development and micromechanical devices required to bring it to fruition.

Goodyear's previous work with Sandia on tread modeling had revolutionized tire design, increased revenue on the sales of the tires by 18%, and resulted in safe and superior tread designs for the consumer, so Goodyear knew the value of having Sandia as technical partner. As it has on more than twenty technically complex projects since the 1990s, Goodyear approached Sandia with another technical challenge, this time to evaluate the feasibility of producing a wireless, passive sensor system with a pressure sensor that could be embedded in tires. There were also many benefits to the Department of Energy in terms of energy use and safety as well as to Department of Homeland Defense applications.

The tire pressure sensing technology investigated involves measuring the delay of radio frequency (RF) pulses absorbed and then re-radiated from a surface acoustic wave (SAW) device and has been demonstrated in rolling tires at speeds up to 80 miles per hour. Sandia and Goodyear designed an inexpensive SAW-based pressure sensor employing multiple SAW transducers on a single substrate that, when coupled with a pressure-sensitive conducting membrane, produced a reflected RF pulse at a specific time and correlated to a specific pressure. The system consists of an active RF transceiver that would be mounted on the car as well as four totally passive pressure sensors mounted in each of the tires.

The sensors were placed in a cavity machined into the material and sealed with a flexible conductive membrane that had a standard pressure in the cavity. When an overpressure was applied to the membrane, it deflected and made contact with conducting levels produced on the interior of the cavity. The ridges were electrically connected to the conductive fingers of the SAW device. When the pressure was high enough to deflect the membrane into one of the conducting levels, selected fingers on the SAW device were grounded, producing patterned acoustic reflections to an impulse RF signal. The timing of the pattern allowed determination of the deflection of the membrane, which in turn was a function of the pressure in the tire.

Tire pressure sensor mounted on the sidewall of a Goodyear Eagle in preparation for rolling tests

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