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# TECHNOLOGY TRANSFER STRATEGIES OF THE U.S. DEPARTMENT OF ENERGY'S CONSERVATION PROGRAM

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DEPARTMENT OF ENERGY

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ENERGY DIVISION

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# EXECUTIVE SUMMARY

This report examines the processes by which research and development (R&D) results funded by the Conservation program of the U.S. Department of Energy (DOE) have generated private-sector interest and involvement and have found commercial applications. The economic problems of the 1980s have drawn attention to the potential benefits that increased commercial innovation could bring to the U.S. economy, and new energy-efficient technologies are particularly important. Any significant savings in energy costs automatically frees up more resources for increased production and further innovation, with the possibility of less dependence on foreign oil and the creation of more jobs in the United States.

A major barrier to innovation is the sometimes tenuous connection between the country's scientific and commercial capabilities. This problem is due in part to the fact that almost one-half of the nation's R&D is federally supported, and much of this R&D activity takes place at federal laboratories and universities, where coordination with industry is often weak.

This report brings together these three vital elements—commercial innovation, energy conservation, and technology transfer—by focusing on the activities of DOE's Conservation program. It provides historical and legislative background to the technology transfer mission of the program and details its economic significance. It also outlines DOE's five main Conservation programs and the various approaches used by each to ensure that their results are put to use.

One of the main themes of the report is the enormous diversity of approaches that can be taken in transferring energy-saving technologies to private- and public-sector users. This diversity mirrors the complexity of the national energy market and private-public interests that often must be negotiated to successfully commercialize an innovation. In many respects, each innovation requires a uniquely tailored technology transfer effort to succeed. However, several methods can serve as guidelines to program managers as they marshal their resources.

Chapter 2 of this report gives a detailed outline of DOE's technology transfer program, with special attention to its management of intellectual property. It also provides an overview of the role that DOE's federal laboratories have played in technology transfer activities.

In Chap. 3, the Conservation program's approach to transferring technologies is detailed. The program places a strong emphasis on applied research; thus, the opportunities for its technologies to lead directly and quickly into new products and processes have been great. The program has stressed the earliest possible involvement of potential private- and public-sector beneficiaries in the process of developing and deploying new technologies. This is illustrated by the fact that industry performs more of Conservation's R&D (43%) than do the national laboratories (39%) or universities (9%). Central to this approach is the belief—verified repeatedly by program experience—that market considerations need to be emphasized in the technological development process. This means identifying clearly

- who the users of a new technology would be,
- how they would use the technology, and
- how they would likely respond to it.

The Conservation program attempts to balance "technology push" and "market pull." Too often in the past, the "push" was the main or only focus of federal R&D assistance efforts, resulting in technologies that literally had no place to go because they were not wanted or could not be profitably adapted by the industry for which they were targeted. Involvement of industry in the total technology transfer picture has been one of the hallmarks of the Conservation program.

Government efforts, however, are not aimed solely at projects that look like an "easy sell." In fact, part of the program's strategy has been to support R&D that is too long-term and risky—financially, technologically, or otherwise—for private investment. This DOE support often encourages subsequent private investment and private research, which is critical given the costs of fully developing new technologies. Data from one Conservation program suggest that for every dollar spent on an initial year of R&D, a total of $35 will be needed to bring the technology to production.

The Conservation program provides a model for national technology transfer efforts in its approach to management. The Conservation emphasis is on decentralization, concentrating management as closely as possible to the inventing organization, and providing incentives and encouragement to those individuals and organizations that have the most knowledge of the matter at hand and the greatest interest in promoting its commercial use. This approach allows the various Conservation programs to employ the kind of "special tailoring" that has proved to be an effective method of supporting technology commercialization.

Chapter 4 details six technology transfer strategies used by the Conservation program. These more general approaches (within which the "tailoring" to each project occurs) include

- contracting R&D to industrial partners;
- working with industrial consortia;
- licensing to industry;
- influencing key decision makers;
- working with trade, professional, and regulatory organizations; and
- generating end-user demand.

These approaches are not mutually exclusive, of course; and in the process of detailing them, the report illustrates some of the ways in which they can be used in tandem. This chapter provides considerable detail on the actual, "hands-on, contact sport" that makes up successful technology transfer. Much of this detail comes in the form of examples of technology transfer efforts that have succeeded, including:

- low-emissivity windows;
- efficiency improvements in the textile industry;
- a tensile-testing system;
- whisker-reinforced ceramics;
- the flame-retention-head oil burner;
- compressed natural gas vehicles;
- unequal parallel compressor systems for supermarket refrigeration; and
- a new cement-grinding technology.

Chapter 5 moves the focus to the unique aspects of each Conservation program's technology transfer activities. The differences are explained in terms of the nature of the audiences being targeted (concentrated vs fragmented), the R&D being conducted (exploratory vs applied), and the reliance on different R&D performers (industry, national laboratories, and universities).

The report ends with a summary of its findings. Available evidence of the effectiveness of the Conservation technology transfer approach is somewhat fragmented and anecdotal but nonetheless persuasive. Particularly impressive is the estimate that 35 Conservation projects have resulted in a national annual energy savings of more than 100 trillion Btu, worth an estimated $350 million at 1986 fuel prices.

# 1. INTRODUCTION

## 1.1 BACKGROUND

Over the past decade, federal policy makers have expressed a growing desire to obtain a better return on federal research and development (R&D) investments through improved technology transfer. The country's future economic productivity and international leadership depend in large part on how well new technologies are put to use to create products, markets, and jobs. Technical innovation and commercial success are the keys to reversing the decline in U.S. international competitiveness, and the development and use of new energy-conserving technologies are of particular importance.

The United States plays a major role in global scientific leadership, and our business infrastructure remains strong in the areas of commercial development and marketing. Yet there appears to be a weak linkage between the nation's capabilities for generating scientific and technological inventions and its capabilities for making effective commercial use of those inventions (President's Commission on Industrial Competitiveness 1985).

The challenge of international competitiveness has motivated both the U.S. Congress and the Reagan Administration to re-examine the adequacy of our federal technology transfer efforts. Because nearly one-half of the nation's R&D is federally supported, the country's future economic well-being is highly dependent upon the successful transfer of research results from the public to the private sector. Technology transfer enhances the benefits of federal funds spent on R&D by putting the resulting knowledge, facilities, and capabilities to use to meet public- and private-sector needs. The result is a greater return on the taxpayer's investment.

The commercialization of conservation innovations could play an important role in improving our economic competitiveness because of its multiple benefits: It can enhance the productivity of our economy, reduce our dependence on oil, and create products for export. In 1987 alone, the country spent nearly $40 billion abroad to pay for oil imports (U.S. Department of Energy 1988a).

Although improved technology transfer processes are a national priority, many dimensions of these processes are poorly understood. Transferring products from producers to consumers, the realm of market research, is fairly well understood; but moving ideas from the laboratory bench to the producer is a different matter entirely, relatively ignored as a generic research problem. As a special case, technology transfer from the public to the private sector has been especially neglected.

> In the rush to bring technology down from the federal shelf to industry's bench, only limited attention has been given to assessment of particular approaches and local effects. . . . For the most part, opinions about the success of technology transfer policies is more a result of casual observation than of systematic inquiry. (Bozeman and Fellows 1988)

This report examines the processes by which R&D results funded by U.S. Department of Energy (DOE) conservation R&D efforts have generated commercial applications. We begin this section by clarifying our use of the term "technology transfer," which has many uses. We then discuss DOE's five conservation programs. The chapter ends with an overview of the remainder of the report.

## 1.2 TECHNOLOGY TRANSFER

Broadly defined, technology transfer is the application of available knowledge or technology by a new user and, in some cases, to a new use (Glaser et al. 1983). In the context of this report, it is the application of government-supported R&D by private- and public-sector users. In this context, there are two types of technology transfer:

- transfer to applications for which the government supported the R&D; and
- transfer to "spin-off" or alternative applications.

The term "technology transfer" is somewhat misleading because it implies that a technology can be picked up from one place and set down in another, as though the transfer process is simply the final step in an R&D program. Indeed, many government programs do start to encourage utilization of research only after the R&D results have been generated. Unfortunately, this "technology push" approach is usually unsuccessful. The most effective approaches to increased research utilization begin much earlier in the innovation process—as far back as when ideas are generated and selected for development (Roberts and Frohman 1979). All too often, technology transfer is blamed for failures in commercialization when the real problem is mistakes in selecting the technologies for development. The nature of the technology developed is a key determinant of whether government-sponsored R&D will yield commercial spillovers. Successful technology transfer and utilization requires close attention to market needs—a clear identification of the users, their needs, and their reactions to types of technological solutions (Myers and Marquis 1969). This is accomplished most effectively through close government-industry collaboration. DOE's Conservation R&D program, through close coordination with private industry, exemplifies this approach to technology transfer.

Public-private cooperation can take many forms, and an appropriate partnership arrangement in one instance may not work well in another. No single mold or model fits because of the complexity of the technology transfer process. While useful "rules of thumb" exist, there is a great deal of variety in the way successful technology transfer occurs. Figure 1.1 shows why this diversity exists.

Technologies originate from many sources—universities, industry laboratories, independent inventors, government agencies, and foreign R&D. These points of origin differ dramatically in terms of the types of barriers that must be overcome to achieve widespread use of the results.

The nature of the technology and research results to be transferred is also diverse and greatly determines the steps needed to ensure transfer and use. Types of results include

- scientific knowledge;
- physical technologies (devices and prototypes);
- technological processes;
- testing techniques and methods;
- technological know-how;
- test results;
- performance data;
- cost/benefit information; and
- patents, copyrights, and other intellectual property.

The channels and audiences appropriate to these different types of results differ dramatically and lead to vastly divergent technology transfer activities. Technology transfer to researchers is different because there is more attention to technical detail and less to economics. Even if a process or product technology is found to be economically unattractive, the research results may still be useful in other applications. Manufacturers, on the other hand, will be particularly interested in cost/benefit information and performance data.

Commercialization of new technologies may involve a business infrastructure of large corporations, small companies, new ventures, or combinations of business types. The goals and resources of these different kinds of businesses vary widely, and the prognosis for successful commercialization is highly dependent upon the match between these goals and resources and the technology's needs.

All of this diversity is mirrored by the range of possible technology transfer approaches available to managers of federal R&D programs.

A key construct used here to sort through this diversity is the innovation development time line. Many elements that influence the appropriateness of different technology transfer strategies change with the transition from exploratory to applied research and also as a technology increases in market penetration and use. For instance, scientific knowledge tends to emerge during exploratory R&D and technology development phases of a project, while performance data and

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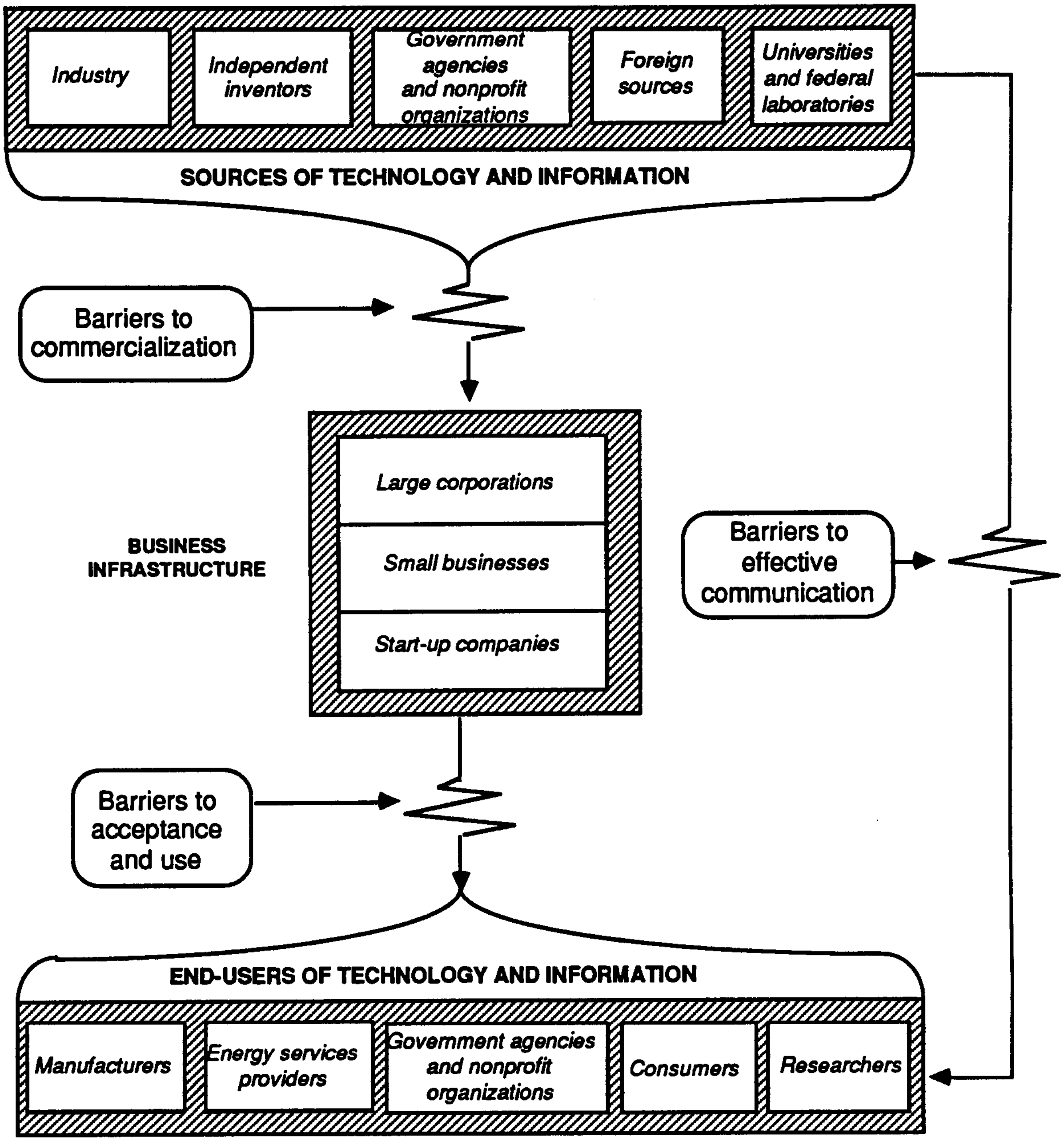


**Fig. 1.1. The technology transfer process.**

cost/benefit information are limited to more mature stages. Key audiences and sources of technology also differ: Government laboratories are more likely to engage in exploratory R&D, while industry laboratories focus more on applied research. Levels of risk, critical barriers, and necessary skills also vary. Figure 1.2 summarizes some of these changes over time.

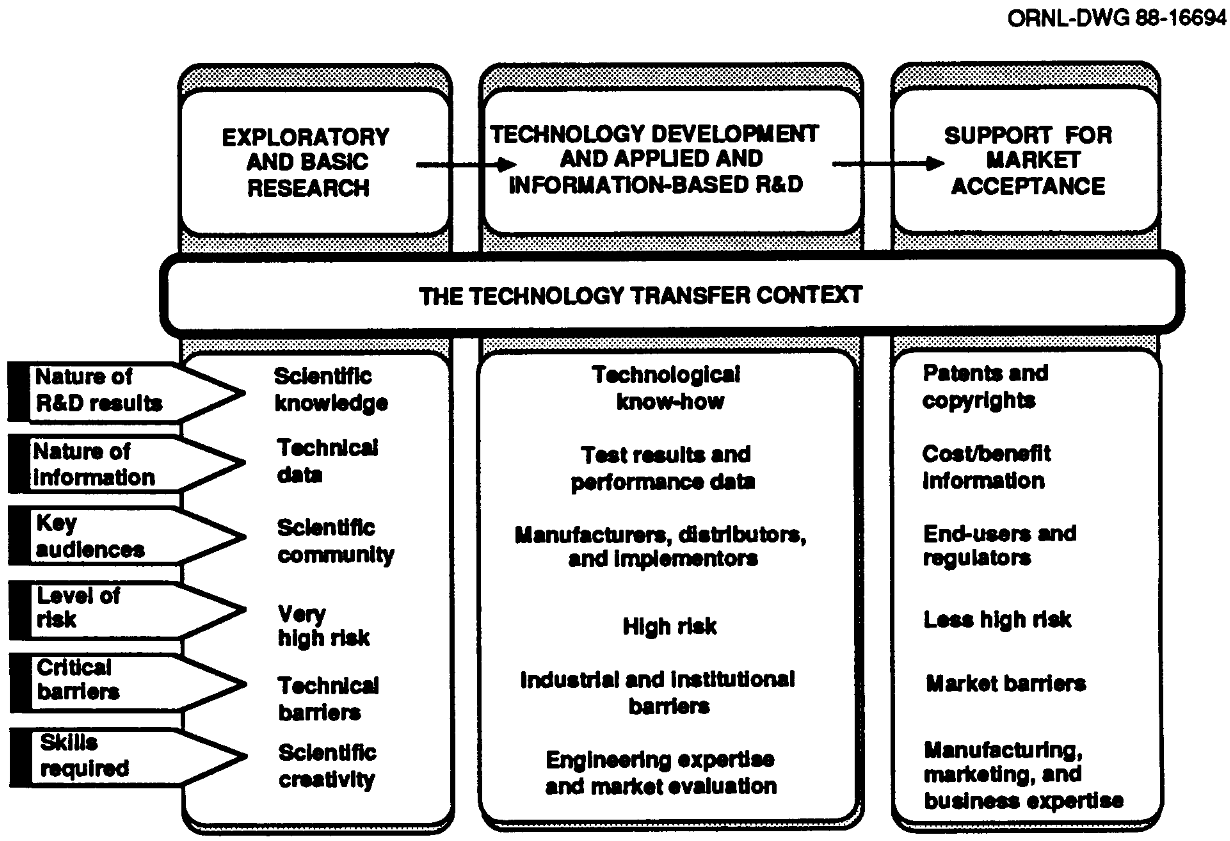


**Fig. 1.2. The technology transfer context.**

## 1.3 DOE'S FIVE CONSERVATION PROGRAMS

The Office of Conservation comprises of five major programs (Fig. 1.3). Three programs correspond to the major energy end-use sectors—buildings, transportation, and industry—and the remaining two are multi-sectoral (the Federal Energy Management Program and the Office of Energy Utilization Research).

Figure 1.4 arrays the individual offices along the innovation time line based on the emphases of their R&D efforts. As will become apparent, the position of each office along this time line explains, in part, why their technology transfer approaches also differ.

### 1.3.1 Industrial Programs

Until 1986, industry was the most energy-intensive sector of the U.S. economy. Of particular significance is the production of chemicals, petroleum, primary metals, paper, stone-clay-glass, and food, which together account for two-thirds of all industrial energy use.

A large potential opportunity exists for improvement in the efficiency of U.S. industrial processes, which are generally less efficient than their foreign counterparts. Between 1974 and 1983, the United States reduced energy consumption per unit output by about 20%. Over the same period, Japan reduced its energy consumption per unit output by about 50% (U.S. Department of Energy 1988a).

Because the manner in which industrial processes use energy is intrinsically linked to overall productivity, technology innovations to improve efficiency can enhance industrial productivity, create products with export potential, and help improve the competitive position of U.S. industry in world markets. To

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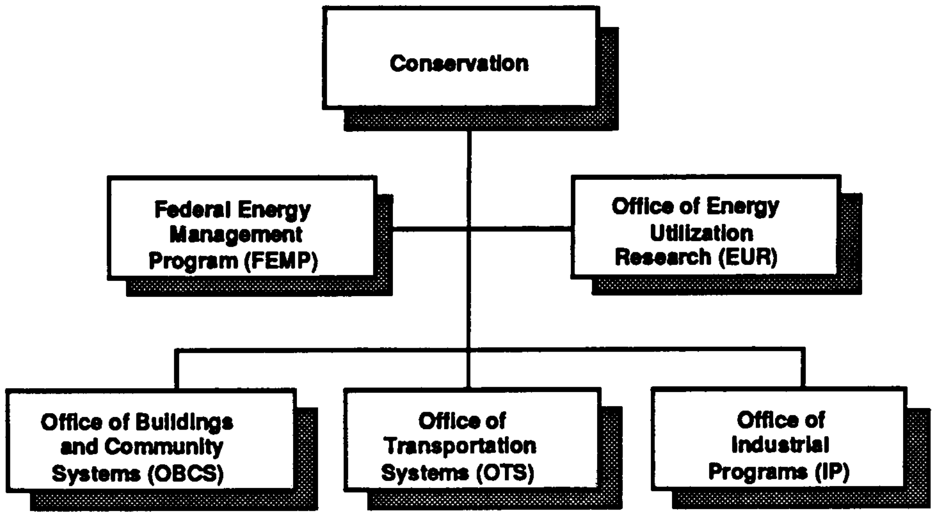


**Fig. 1.3. DOE's five Conservation programs.**

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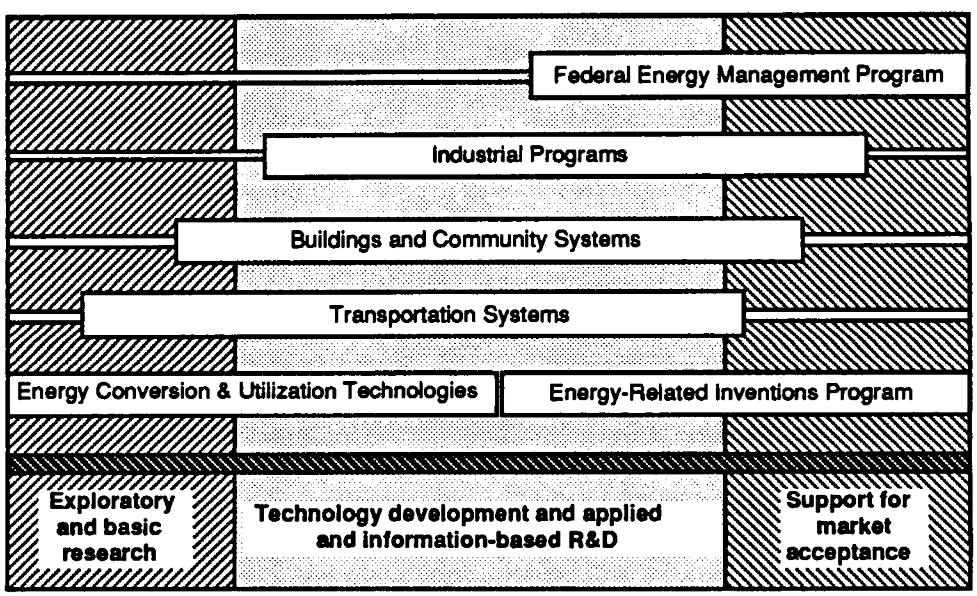


**Fig. 1.4. R&D emphases of the five Conservation offices.**

address the energy conservation needs of this key economic sector, DOE's Office of Industrial Programs (IP) sponsors research aimed at improving the energy efficiency of industrial processes and energy conversion equipment. IP develops systems for the simultaneous production of electricity and process heat (cogeneration) and explores the potential of technologies that can use multiple fuels. The office also seeks to ensure that the technologies it develops are environmentally sound.

Industrial energy conservation program activities are grouped into four program areas: waste energy reduction, industrial cogeneration, improved energy productivity, and implementation and deployment.

### 1.3.2 Transportation Systems

Transportation accounts for 63% of U.S. oil consumption and is projected to use 22% more oil in 1988 than is produced domestically. At this time there is no economically feasible substitute for oil. However, there is great potential for saving energy through the development of cost-effective fuel oil substitutes and more efficient energy-using technologies. While average new car fuel economy has increased by about 10 mpg since 1973 and aircraft operating efficiency has improved by about 90%, the transportation use of petroleum continues to rise because the demand for travel continues to grow. At the same time, the transportation sector's reliance on oil remains near 100% (U.S. Department of Energy 1988a).

To exploit the sector's potential to save energy and reduce oil dependence, the Office of Transportation Systems (OTS) focuses on promising engine technologies that are not likely to be developed by the private sector alone because of their high-risk and long-term applications. Projects focus on innovative materials, advanced engines, alternative fuels, and electrically powered vehicles.

OTS is divided into two major research areas: Electric and Hybrid Propulsion and Heat Engine Propulsion. The Electric and Hybrid Propulsion Division addresses the need for improved range, reliability, cost, and performance of electric and hybrid vehicle alternatives to petroleum-fueled vehicles. The focus is on advanced electric vehicle battery and propulsion system technology, hybrid and advanced component R&D, and fuel cell development. The Heat Engine Propulsion Division focuses on automotive heat advanced engine systems and technology development. Areas of emphasis include automotive gas turbine and automotive Stirling engine development, advanced diesel components and materials, transportation waste-heat utilization, alternative fuels utilization, and advanced materials.

### 1.3.3 Buildings and Community Systems

The buildings sector consumes more than 35% of the primary energy in the United States, approximately 27 quads. By the year 2010 this total could be 39 quads. A major national effort to conserve energy in the buildings sector could save 20–30% of this total over the next 20 years, a potential savings worth $87 billion in 1986 dollars.

The Office of Buildings and Community Systems (OBCS) leads a national program to increase the efficiency of energy use in the buildings sector through a program of applied research, technology development, and technology transfer. The OBCS research effort is focused on five key building systems: building envelopes, building equipment, indoor air quality, lighting, and design and construction systems.

In addition, OBCS encourages community energy management by localities throughout the United States; conducts R&D on the centralized production and distribution of heating and cooling; and, through its recently initiated Least-Cost Utility Planning Program, conducts research on the integration of demand-side management and energy supply options in planning by electric utilities.

Evidence of the effectiveness of the OBCS technology transfer program is provided in a recent set of 12 case studies. It shows that cumulative energy savings for three innovations supported by OBCS (i.e., the flame-retention-head oil burner, low-emissivity (low-E) windows, and solid-state ballasts) have been approximately 0.2 quad and are likely to approach 2 quads by the year 2000 (Brown, Berry, and Goel 1988).

### 1.3.4 Energy Utilization Research

The Office of Energy Utilization Research (EUR) sponsors research that promotes greater understanding of fundamental concepts for engineering application across all the energy end-use sectors. The program has elected to focus specifically on research in the areas of combustion and thermal sciences, materials, catalysis/biocatalysis, and tribology.

The largest program within EUR focuses on Energy Conversion and Utilization Technologies (ECUT). Emphasis is placed on research in technologies and processes that are well conceived technically, that promise significant energy savings and cost effectiveness, and that are too generic for other DOE conservation programs and private firms to pursue. Through improved understanding of the scientific principles underlying the fundamental processes in energy conversion and use, it is possible to develop new, sometimes revolutionary, approaches to using energy more efficiently. This research attempts to bridge the gap between today's process efficiencies and realistic theoretical potentials, subject to constraints based on likely costs of energy and technology.

EUR also supports the Energy-Related Inventions Program (ERIP) and the Innovative Concepts Program (ICP), two efforts that focus on accelerating the market introduction and diffusion of new technologies. ERIP promotes the commercialization of promising energy-related inventions developed by individual inventors and small businesses. The National Institute of Science and Technology (NIST) evaluates the inventions and recommends promising ones to DOE for further assistance. DOE then provides direct support to the inventors in the form of technical, managerial, business, and financial assistance. To date, more than 440 inventors have been recommended to receive support from ERIP, and sales generated by ERIP technologies have totaled nearly $300 million (Brown and Snell 1988).

The overall goal of ICP is to increase the number of advanced concepts for saving energy and improving industrial productivity. ICP seeks out innovative concepts that save energy, provides seed money contracts, and then conducts Innovative Concepts Fairs at which the concepts are exposed to public scrutiny.

### 1.3.5 Federal Energy Management Program

The Federal Energy Management Program (FEMP) is charged with improving the energy efficiency of buildings, transportation, and industrial processes that are owned and operated by individual federal agencies. More efficient use of energy by the federal government, the largest single energy consumer in the nation, presents considerable opportunities for saving energy and reducing federal expenditures. The cost of federal energy use has varied between $12 billion and $15 billion annually in recent years, amounting to about 2.5% of all U.S. energy consumption.

FEMP is designed to reduce the level of energy consumption by all branches of the federal government and to alter the fuel mix to reduce dependence on oil. This is accomplished through the establishment and tracking of energy efficiency goals, the development and distribution of energy-use auditing and forecasting tools, the dissemination of information to effect the transfer of applicable energy management experience and technologies from the private sector to and among federal agencies, and the reduction of institutional barriers to improved energy-use efficiency in federal facilities. FEMP is also supporting new energy management initiatives such as use of multiyear "shared energy savings" contracts to finance building retrofits in the federal sector. This type of contract with energy service companies allows federal agencies to improve the energy efficiency of their buildings at no direct capital cost.

## 1.4 PURPOSE AND ORGANIZATION OF THIS REPORT

This report documents and explains the technology transfer activities of DOE's Conservation program. It begins by outlining federal and DOE policy on technology transfer and the role of DOE national laboratories in commercializing federally funded technologies. It also describes some of the major barriers to the transfer of energy-conserving technologies (Chap. 2). It then explains the overall technology transfer strategy of DOE's Office of Conservation, including its management approach to technology transfer and some of its technology, program, and technical successes (Chap. 3).

Six alternative methods used to commercialize conservation technologies are described. The advantages and disadvantages of each method are discussed, and illustrations based on Conservation program experiences are provided (Chap. 4). The unique technology transfer features of each of the office's major programs are then described in terms of these alternative approaches (Chap. 5). The report ends with a summary of its findings (Chap. 6). Throughout, notable technology transfer efforts undertaken within the office are highlighted to illustrate the more general discussion.

# 2. DOE'S TECHNOLOGY TRANSFER PROGRAM

The commercialization of conservation technologies is affected by policies and procedures that are implemented at many levels and by many units within DOE. The technology transfer policies and procedures of DOE, its national laboratories, and its Office of Scientific and Technical Information are described in this chapter. Chapter 3 focuses more specifically on the technology transfer approach of the Office of Conservation and its various programs—the shaded boxes shown in Fig. 2.1.

## 2.1 FEDERAL AND DOE POLICY ON TECHNOLOGY TRANSFER

Federal policy has evolved over the last four decades to make technology transfer an integral part of federal agency missions. This is particularly true for R&D-oriented agencies. The policy is contained in legislation, policy directives, Presidential statements, and congressional budget allocations and mandates.

The most noteworthy recent technology transfer legislation is the Stevenson-Wydler Technology Innovation Act of 1980 (P.L. 96-480) as amended by the Federal Technology Transfer Act of 1986 (P.L. 99-502). The Stevenson-Wydler Act increased the effort devoted to technology transfer by requiring that (1) government agencies devote 0.5% of their R&D budgets to technology transfer, (2) each federal laboratory with a budget in excess of $20 million commit a minimum of one full-time staff person to technology transfer, and (3) each

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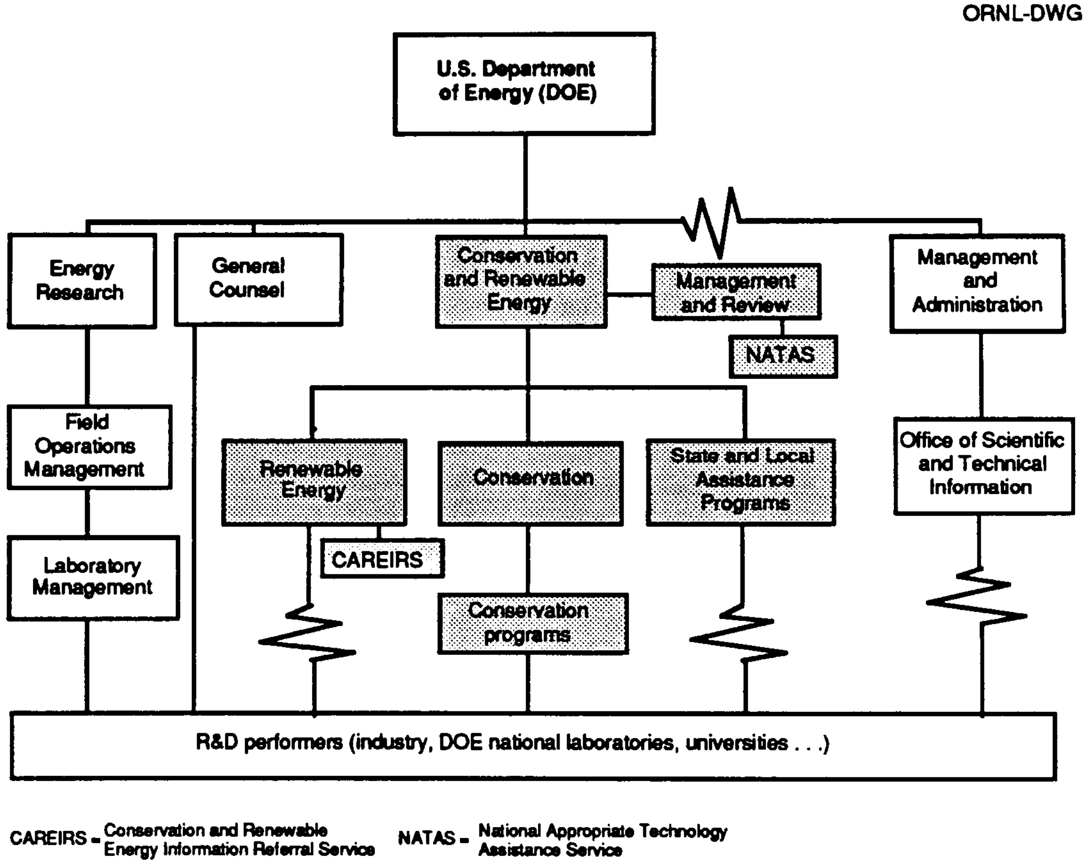


Fig. 2.1. DOE units involved with the technology transfer program of the Office of Conservation.

federal laboratory establish an Office of Research and Technology Applications (ORTA). The act defined the functions of the ORTAs as

- assessing each R&D project for its potential use in non-federal areas;
- providing and disseminating information on federal R&D results;
- cooperating with other federal technology utilization efforts to promote the non-federal use of new products, services, and processes; and
- providing technical assistance to state and local government officials.

The 1986 Federal Technology Transfer Act required that incentives be established by government-operated laboratories to encourage more effective technology transfer, including royalty sharing and consideration of technology transfer accomplishments in evaluating and promoting scientists and engineers at federal laboratories. It also strengthened the Federal Laboratory Consortium (FLC) for Technology Transfer by aligning it with NIST and providing funds from a tax of 0.005% on all federal agencies. Finally, the act formalized the role of the National Technical Information Service (NTIS) in licensing activities and disseminating technical information, including the performance of various functions originally outlined for the Center for the Utilization of Federal Technology (CUFT) in the 1980 Stevenson-Wydler Act.

Changes in federal and DOE policy regarding patents, copyrights, and intellectual property activities have dramatically improved access of the private sector to technologies developed by federally sponsored R&D. Before 1980, most federal agencies routinely took title to all inventions created with federal funds and attempted to license their technologies to qualified applicants. This approach was generally viewed as ineffective in achieving commercialization; only 5% of the more than 25,000 federally owned patents have been licensed to non-government entities.

In recent years, several federal agencies, including DOE, have used their authority to routinely grant advance and identified waivers to their contractors. As a result, the commercial rights to about 40% of DOE's patents have been waived or licensed to nongovernment entities (D. R. Fitzpatrick, Assistant Secretary, Conservation and Renewable Energy, DOE, memorandum entitled "Under Secretary Approval of Task Force Report," April 15, 1988). DOE laboratory contractors retained patents to more than 162 inventions in 1986 (U.S. Department of Energy 1988b). The dramatic changes to federal and DOE patent policy that have facilitated DOE's improved rate of success are summarized in Fig. 2.2.

A recent DOE task force on intellectual property concluded that other actions could be taken to improve the department's intellectual property activities. Similar recommendations emerged from a review of constraints to technology transfer, as perceived by federal laboratory and agency officials (U.S. Government Accounting Office 1988).

- Greater protection of technical data generated under cost-shared contracts is needed.
- Regulations are needed that would simplify advance patent waivers to large business contractors for classes of inventions.
- Blanket approval should be provided to DOE GOCO contractors to copyright and license software developed in the course of DOE-funded R&D efforts.

Some of these problems may be solved by DOE's three Superconductivity Research Centers (SRCs). The SRCs were recently established, in part, to create innovative ways of facilitating cooperative R&D. It is hoped that they will improve U.S. industrial competitiveness by accelerating the high-temperature superconductivity research-to-product development cycle. Areas of concern are

- improving the protection of proprietary information divulged in the course of cooperative research;
- providing a flexible, responsive, and timely approach to government/industry cooperation; and
- maximizing the usefulness and transfer of patents and intellectual property to industry.

**FEDERAL AND DOE POLICY REGARDING INTELLECTUAL PROPERTY**

**1974** Section 9 of the Federal Nonnuclear Energy R&D Act gave the Energy Research and Development Administration (ERDA) the authority to waive the government's rights to inventions coming out of its contracts.

**1980** The Stevenson-Wydler Act of 1980 (Public Law 96-480) made technology transfer a responsibility of the national laboratories, where appropriate and consistent with mission responsibilities. The Bayh-Dole Act (P.L. 96-517) established the general rule allowing small businesses and nonprofit organizations in most instances to retain title to inventions conceived while under contract to the federal government. It also encouraged the licensing of government-operated laboratory inventions by authorizing federal agencies to grant exclusive and partially exclusive licenses.

**1983** A Presidential Memorandum of Government Patent Policy, dated February 18, 1983, directed agencies to give all federal contractors the same rights to inventions as small business and nonprofit grantees and contractors. Federal agencies may grant identified invention waivers to contractors operating government-owned laboratories on a case-by-case basis.

**1984** The Bayh-Dole Act was amended by P.L. 98-620, giving nonprofit contractors operating government-owned laboratories the same patent rights as small businesses and nonprofit organizations. Of DOE's 14 nonprofit contracts, 11 were amended. Guidelines concerning royalty sharing, use of royalties at the facility, and conflict of interest were included in the procurement instructions of these contracts.

**1985** On February 5, 1985, DOE Secretary Hodel signed a new department patent policy extending the provisions of the recent patent legislation to for-profit contractors. Thus, contractors of all DOE laboratories (including for-profit, large businesses) could maintain ownership of inventions arising from federally supported research conducted at their facilities.

**1986** The Federal Technology Transfer Act of 1986 (P.L. 99-502) was passed. The intent of the act is to facilitate cooperative R&D, while protecting the legitimate concerns of the government. Under the act, a laboratory can grant a collaborator title or licensing rights to any resulting invention; but if the collaborator takes title to an invention, the government retains a royalty-free license for its use by or on behalf of the government.

**1987** President Reagan's Executive Order 12591, "Facilitating Access to Science and Technology," directed federal agencies to improve the transfer of federally developed technology and technical information by licensing, assigning, or waiving intellectual property, implementing royalty-sharing programs for federal inventors, and developing a uniform federal policy permitting federal contractors to retain rights to software, engineering drawings, and other federally generated technical data.

**Fig. 2.2. Federal and DOE policy regarding intellectual property activities.**

These centers are test beds for new ideas for improved technology transfer policy.

## 2.2 DOE'S FORMAL TECHNOLOGY TRANSFER PROGRAM

In response to the Stevenson-Wydler Act and the Federal Technology Transfer Act of 1986, DOE has developed a laboratory Technology Transfer Program. This program provides guidelines for technology transfer to DOE beneficiaries in both the U.S. public and private sectors, and it records and monitors the success and effectiveness of the programs at DOE laboratories.

The Technology Transfer program also helps disseminate information about available technology through publications such as *Technology*, an annual document targeted at industry, universities, Congress, and other federal agencies. In addition, industry-laboratory personnel exchanges are supported by the program (Energy Research Advisory Board 1988b).

## 2.3 THE ROLE OF NATIONAL LABORATORIES

R&D is performed for DOE by national laboratories, industry, universities, other government agencies, and nonprofit organizations. Because a majority of DOE's R&D funding is either managed or conducted by national laboratories, these laboratories are central to the department's technology transfer efforts.

DOE requires its laboratories to establish a technology transfer focus and to include technology transfer as important mission activities in conjunction with their respective technology mission assignments. While there is close coordination between DOE and the national laboratories in technology transfer, each laboratory has some flexibility to design and carry out its own technology transfer program to best fulfill its goals and modus operandi. Several DOE laboratories have elected to develop adjunct organizations responsible for licensing and marketing their new technology and software (U.S. Department of Energy 1988b). Some of the more prominent examples of these are described here.

The Argonne National Laboratory–University of Chicago (ARCH) Development Corporation was established as a nonprofit joint partnership between the University of Chicago and Argonne National Laboratory (ANL). It takes title to selected inventions by university and Argonne staff for commercialization. It works closely with ANL's Technology Transfer Center, which contains the Office of Research and Technology Applications and coordinates with the technical divisions through a network of divisional Technology Transfer Representatives. To date, ARCH Development Corporation has applied for rights to 13 patents, and in 1987 it completed its first two licensing agreements (U.S. Department of Energy 1988c).

At Ames Laboratory, Edge Technologies, Inc., was established to provide the organization and resources to commercialize technology from that laboratory and Iowa State University. Several large Iowa-based businesses are providing capital, business leadership, and other resources to further spur regional economic development. Edge Technologies has recently succeeded in licensing its first technology.

The Battelle Development Corporation is the organization responsible for commercializing technologies and software developed from Pacific Northwest Laboratories (PNL) research. It issued nine licenses for PNL technologies in 1987. Within PNL, a separate directorate established for Technology Transfer reports to the director of the Laboratory. Offices responsible for conducting technology transfer activities include the Office of Research and Technology Applications, Office of Industrial Programs, and the Office of Innovation and Technology Development (U.S. Department of Energy 1988b; 1988c)

Martin Marietta Energy System's Office of Technology Applications is responsible for transferring technologies developed by Oak Ridge National Laboratory (ORNL). By mid 1988 it had issued 23 licenses for laboratory technology and software—more than any other federal laboratory. The strategy that has promoted this success is summarized in Fig. 2.3.

## 2.4 THE OFFICE OF SCIENTIFIC AND TECHNICAL INFORMATION

"Science transfer" is strongly supported by DOE's Office of Scientific and Technical Information (OSTI). OSTI maintains databases of publications, publishes and distributes technical reports, and operates a clearinghouse for energy-related software. The Office of Conservation relies on OSTI for much of its "passive" technical information exchange. Of particular note are the Current Awareness Bulletins published periodically by OSTI for many of Conservation's individual offices. Current Awareness Bulletins include

- *Industrial Energy Conservation,*
- *Buildings Energy Technology,*
- *Transportation Energy Research,* and
- *Energy Conversion and Utilization Technologies.*

These bulletins contain overviews of the DOE Conservation programs, abstracts of recent publications, and other information of interest to the scientific community.

**THE TECHNOLOGY TRANSFER PROGRAM**
**AT OAK RIDGE NATIONAL LABORATORY (ORNL)**

ORNL's technology transfer strategy is implemented by Martin Marietta Energy Systems' Office of Technology Applications (OTA).

**OTA fosters technology transfer through staff incentives:**

- Inventors of patented, licensed, royalty-bearing innovations receive 10% of the royalties (up to $100,000 per invention).
- Authors of copyrighted, royalty-bearing material receive 10% of the royalties.
- Staff who make an extraordinary effort to ready an innovation for industrial use receive 4% of the royalties that the innovation reaps.
- The "Inventor of the Year Award" recognizes the inventor of the most significant technology each year.
- An annual patent award luncheon recognizes inventors receiving patents during the year.
- An internal Inventor's Forum allows patent-holding employees an opportunity to meet and discuss issues of common concern.

**OTA facilitates technology transfer through information exchange:**

- OTA publishes and distributes Technology Applications Bulletins, which contain articles about new ORNL technologies and lists of patented ORNL technologies available for licensing.
- OTA funds temporary positions for scientists and engineers in industry to work side by side with ORNL scientists and engineers.

**OTA actively promotes commercialization by**

- evaluating available and emerging technologies;
- supporting the maturation of technologies that require significant development work to ready them for commercialization, through funds from royalty revenues;
- securing the proper protection and rights to intellectual property;
- conducting manufacturer surveys to determine appropriate commercial client firms;
- negotiating and placing technology licenses;
- providing technical support to technology clients; and
- managing revenues from licensing to maximize future technology transfer.

**Fig. 2.3. The technology transfer program at Oak Ridge National Laboratory.**

## 2.5 BARRIERS TO THE TRANSFER OF ENERGY TECHNOLOGIES

There are many barriers to the commercialization of DOE's energy conservation technologies. These include

- unstable, inconsistent, and insufficient DOE funding for conservation R&D and technology transfer;
- protracted patent and licensing procedures;
- a cumbersome conference approval process; and
- constraints on technology demonstration activities.

Other barriers are more generic in nature. These include:

### Market Barriers

- Uncertainty about future energy prices—this diminishes the ability of both industry and individuals to invest in new conservation technologies.
- Waning interest in energy conservation technologies.
- Foreign competition—this adds risk to the development and introduction of new energy-efficient technologies by U.S. companies.
- Misplaced incentives resulting in an emphasis on first costs rather than life cycle costs.
- Imperfect ability of the housing and commercial building market to capitalize fuel savings into market values.

## Industry Barriers

- Limited resources for private-sector R&D.
- Resistance to change/institutional inertia.
- Outdated standards.
- Safety and reliability considerations.

## Information Transfer Barriers

- Information overload—the volume of technical information is so large that potential users are overwhelmed and unable to sort through it. From industry's perspective, the cost of screening volumes of federal research is great, and the probability of identifying useful technologies is low.
- Technical information from research laboratories is often not presented in formats readily usable by practitioners and industry decision makers.
- Uncertainties about the cost effectiveness of using new energy-efficient technologies and lack of confidence in energy savings.
- Lack of an adequate information clearinghouse for information on energy conservation R&D.

# 3. THE CONSERVATION PROGRAM'S APPROACH TO TECHNOLOGY TRANSFER

The Office of Conservation has benefitted from DOE's more aggressive technology transfer efforts. At the same time it has taken a leadership position within DOE in implementing innovative and effective technology transfer approaches. This leadership role stems, in part, from Conservation's relative emphasis on applied research. By its nature and the original intent of the program, the Office of Conservation has tended to support research that is more short-term than other DOE activities. Thus, the opportunities for its technologies to lead directly and quickly into new products and processes have been great, and the office has been oriented to taking advantage of these opportunities.

## 3.1 MAXIMIZING INDUSTRY INVOLVEMENT

The office's technology transfer role is that of facilitator and catalyst to the commercialization and use of cost effective, energy-efficient technologies. Its modus operandi is to provide maximum private-sector involvement in both the identification and solution of R&D problems. With significant input from industry, trade and professional associations, universities, and others, research needs are identified, research agendas are set, research projects are undertaken, and results are evaluated.

Industry involvement tends to be initiated early in the R&D process, facilitating the clear identification of users, user needs, and user reactions to types of technological solutions before the problem solving actually begins. The office's technology transfer approach depends as much on market needs as on technological opportunities—a proper balance between "technology push" and "market pull." Its emphasis on early industry involvement helps define a conservation agenda that emphasizes "transferable" technologies.

At the same time, collaborative R&D can influence industry's research priorities. Industry involvement in DOE-sponsored research has encouraged industry to invest in R&D related to the energy-efficiency issues of interest to the office. Stimulating research by individual firms seeking to develop commercial applications is essential to successful technology transfer.

Only a small fraction of the total cost of technological innovation is devoted to the basic research leading to the invention, concept development, and feasibility testing. The vast majority of innovation development costs are expended in engineering design, prototype development, production engineering, tooling up, manufacturing start-up, and marketing. Data from ERIP suggests that for every dollar spent in an initial year of R&D, a total of $35 will need to be spent to bring the technology to production. A time line of development costs based on 65 successful ERIP inventions is presented in Fig. 3.1.

Since the government tries to avoid financing research that would have been performed in any event, it tends to support only the first several stages in the development of an innovation. To achieve commercial application it must successfully convince industry that further private investment is warranted. Involvement by industry in the office's R&D planning and sponsored research helps to accomplish this, as does cost sharing during the technology development phase. The transition from fully subsidized R&D to industry research without government support is illustrated in Fig. 3.2.

The emphasis given to cost sharing is underscored by the fact that in FY 1988, DOE's Conservation projects received $73 million of support from other sources, nearly one-half of its congressionally appropriated budget (Fig. 3.3). Most of this cost sharing was provided by industry, although universities and other government agencies were also active co-supporters of the Conservation R&D effort.

The strong involvement of industry is also indicated by the frequent use of industrial contractors as performers of Conservation R&D. In FY 1988, 43% of the Conservation R&D budget went to industry, and 39% supported R&D conducted at national laboratories (Fig. 3.4).

ORNL-DWG 88-16699

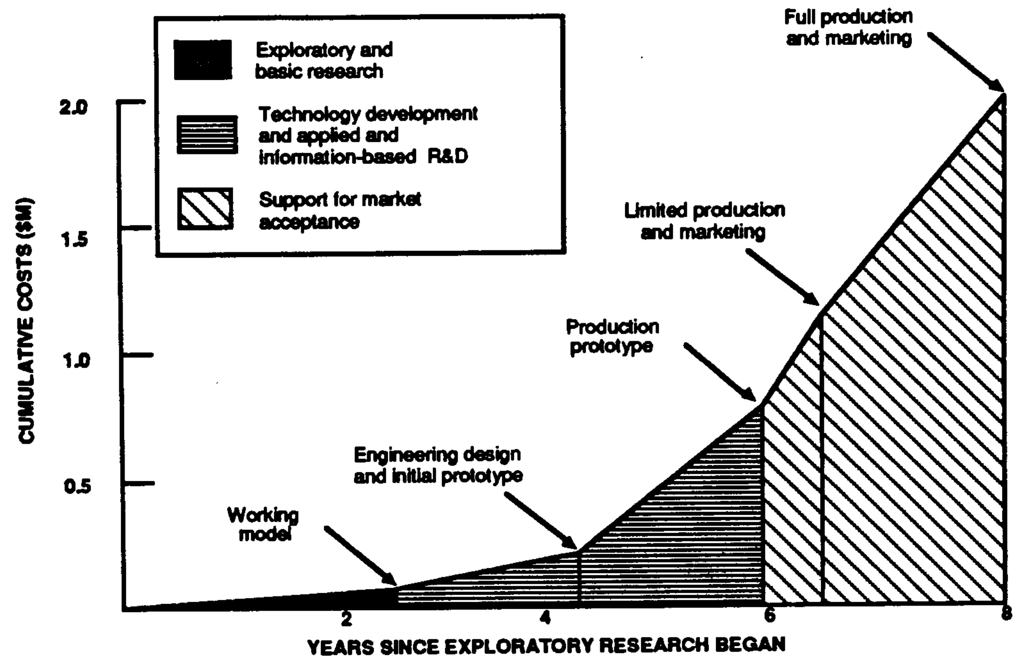


**Fig. 3.1. Technology development and commercialization costs.** *Source:* M. A. Brown and S. A. Snell 1988. *The Energy-Related Inventions Program: An Assessment of Recent Commercial Progress,* ORNL/CON-252, Oak Ridge National Laboratory, Oak Ridge, Tenn.

ORNL-DWG 88-16700

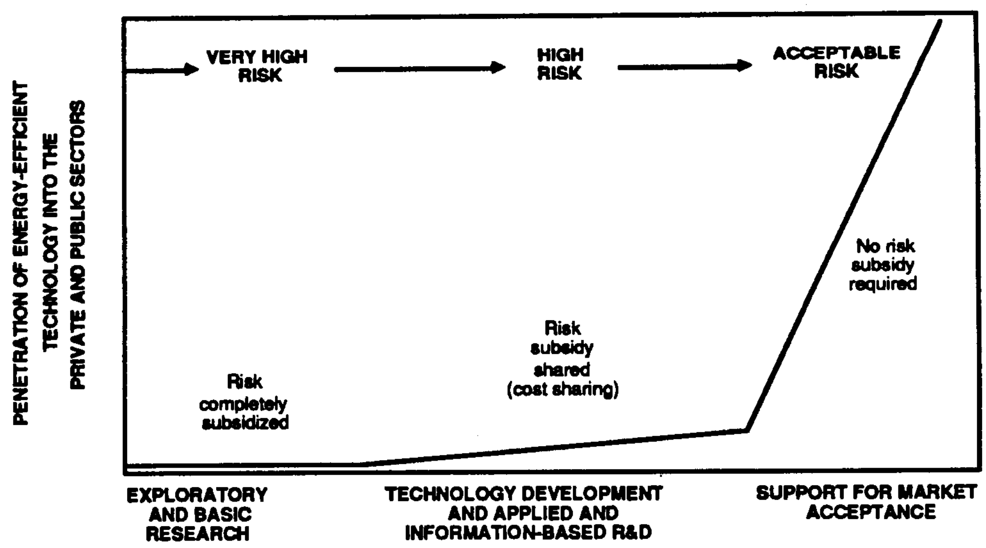


**Fig. 3.2. The technology transfer approach of DOE's Conservation program.**

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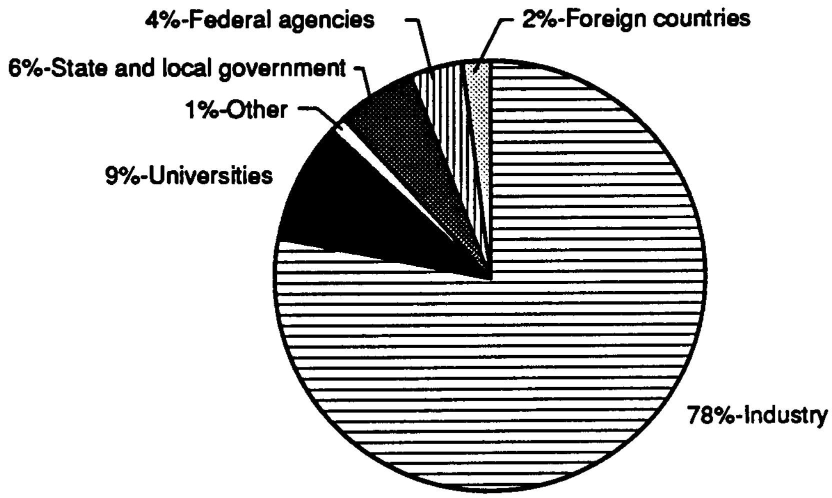


**Total cost sharing in FY 1988 = $73 million**

**Fig. 3.3. Sources of cost sharing for Conservation's R&D program in FY 1988.**

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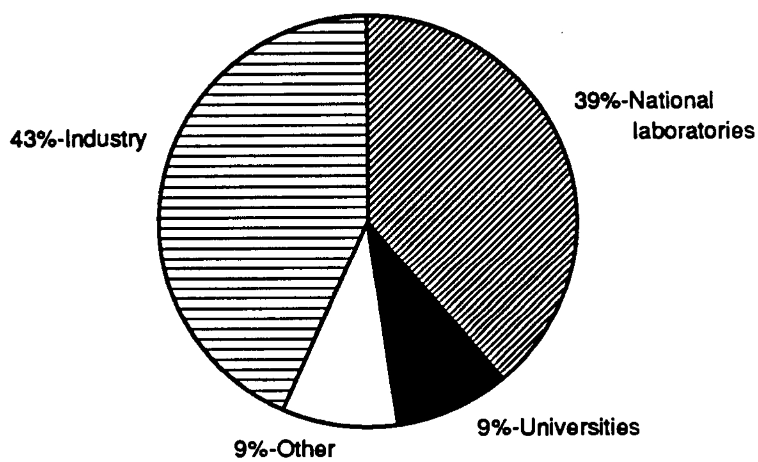


**Total Conservation budget in FY 1988 = $156 million**

**Fig. 3.4. Performers of DOE's Conservation R&D in FY 1988.**

## CATALYTIC DISTILLATION

Catalytic distillation is a simple and efficient method of producing hydrocarbons, including octane-increasing gasoline additives. Because the reaction that produces these hydrocarbons is reversible and the propensity for a reverse reaction increases with temperature, the yield is maximized by removing the product from the reaction zone and removing the heat of reaction. The conventional procedure requires reiterative reaction and product separation steps until the concentration of product and reactants is too low for further economical separation. Catalytic distillation, however, combines the two steps in one vessel by using the exothermic heat of reaction to facilitate the product's continuous removal from the reaction zone by distillation. This method provides over 99% conversion of reactants to product and energy savings as high as 60%.

The process was developed and patented by Chemical Research and Licensing Co. (CR&L), but CR&L lacked the financial backing to complete the R&D and commercial demonstration necessary to commercialize the process. Without a full-scale, long-term demonstration of the innovation's performance, petroleum companies were unwilling to spend the money to install the process into their refineries; they could not risk interruption of oil production, which would cost them millions of dollars.

In 1980, CR&L and Neochem Corp., in a joint venture, received DOE backing to test, demonstrate, and develop the process at the Charter International Oil Co. refinery in Houston. One condition that Charter imposed was that if the new technology didn't perform adequately for 1 year (i.e., if they could not retain 80% of their activity), then Charter would be reimbursed by DOE for the cost of the catalyst. The cost of new catalyst was actually written into the contract. As it turned out, the catalyst did fail due to too much moisture in the raw materials, and DOE paid $280,000 to replace it. The problem was solved by installing a drying system, after which the viability of the method was established, and the road to commercialization was paved. It is highly unlikely that the innovation would have been commercialized without the DOE support.

In 1982, additional DOE funds were used to contract the CR&L/Neochem team to research other promising applications of the process. A unique feature of this contract was that it specified a "payback" to DOE of up to $200,000 of the royalties earned by the CR&L/Neochem team. CR&L was not earning any money at the time the contract was negotiated, so this was the only cost sharing that they could offer. The $200,000 was returned to the U.S. Treasury, reducing the total government cost for the 1980 and 1982 involvement from $1.5 million to $1.3 million.

Catalytic distillation has had extensive commercial impact. There are currently eight units operating, and two more have been licensed and are under construction. Private-sector R&D has been expanded, and applications to other compounds are being developed. It is expected that in the near future the catalytic distillation process will be used both for isobutane isolation (giving energy savings of greater than 20% over the old process) and for utilizing waste gases from refining to produce high octane gasoline.

The energy savings from catalytic distillation are estimated to be 235 billion Btu per year in recent years,730 billion Btu to date through 1987, and 43.3 trillion Btu by the year 2010.

**Fig. 3.5. The commercialization of catalytic distillation.**

Universities, state and federal agencies, and others play a much less extensive role in R&D.

Innovative approaches are often necessary to achieve active industry involvement. For example, several novel forms of "gainsharing" and "risksharing" were tested in the case of catalytic distillation—a technology developed with IP funding. First, since the R&D contractor for this technology was small and cash poor, a royalty "payback" was substituted for an up-front cost sharing. By waiving the typical requirement of 20% cost sharing but requiring a share of the resulting revenues (i.e., gainsharing), DOE enabled a small firm to participate that would otherwise have been unable. Second, to attract the involvement of a petroleum company in the demonstration of the technology, DOE included a form of insurance in its contract. Reimbursement for the cost of catalyst was included in the contract in the event that the catalyst failed during the demonstration. This form of risksharing was essential to the success of the project, which required installation of the technology in an operating plant (Fig. 3.5).

## 3.2 THE MANAGEMENT OF TECHNOLOGY TRANSFER

Within large R&D organizations, a decentralized approach to technology transfer is considered by many authorities to be the most efficient (N. J. Latker, Director, Federal Technology Management Policy Division, personal communication to Directors of Federal Laboratories, May 10, 1985). Such an approach is employed within the Office of Conservation.

Technology transfer activities are undertaken by each of the Conservation programs. These activities tend to be crosscutting in nature rather than specific to individual technologies. For instance, market and technology assessments are conducted to identify the R&D products that are ready for transfer as well as potential customers and clients, their needs, and the way they adopt and adapt to new technologies.

When results are available, outreach and education activities are undertaken to promote use of the products. Several examples of these "program-wide" activities are listed here.

- The **Energy Analysis and Diagnostic Center Program** sponsored by IP uses the services of 13 major engineering schools across the nation to provide energy conservation audits to small and medium-sized manufacturing firms. Faculty members (registered professional engineers) direct the work of advanced students who do the actual audits.
- **Electric Vehicle (EV) Users' Meetings** sponsored by OTS are held with site operators, the EV Users' Task Force, DOE research laboratories, and representatives from the manufacturing industry. At these workshops site operations are discussed and potential product improvements, such as refinements in vehicle performance and reductions in operating costs, are identified.
- **Institutes for Engineering and Architecture Educators** have been sponsored on an annual basis by OBCS. These institutes maintain awareness among faculty members of energy as a major curricular issue and provide a means for information transfer from OBCS programs to universities. They also provide a forum for exchange of information on current and planned research among representatives of government, private industry, and the academic community.
- **Commercialization Planning Workshops** sponsored by ERIP (within EUR) are three-day workshops for inventors whose technologies have been recommended to the program. At these workshops, inventors are instructed by recognized professionals in the fields of technical development, business development, marketing, licensing, and financing. Up to 12 inventors attend each of the 4 workshops held each year.
- ***Federal Energy Management Program Update*** presents articles of current interest on program developments, technology transfer, and training opportunities. It is intended to encourage energy conservation and implementation of energy management techniques among government energy managers.

A new educational initiative by OTS has just been launched—the Methanol Marathon. It is designed to encourage future engineers to work on automotive technologies of national importance (Fig. 3.6).

Within these offices and programs, however, the bulk of the technology transfer effort is funded and managed by individual Conservation program managers as part of their R&D project efforts. Generally speaking, these managers are most familiar with the R&D products that need to be transferred, the recipient audiences, barriers to change, and the transfer mechanisms that will be most effective. The nature of these technology transfer efforts is characterized in Chap. 5.

To supplement this decentralized approach, the Office of Conservation capitalizes on the technology transfer programs of DOE as a whole and its laboratories. Services of the Conservation and Renewable Energy Information Referral Service (CAREIRS) and the National Appropriate Technology Assistance Service (NATAS) are also widely used.

**THE METHANOL MARATHON**

In the spring of 1989, 15 teams of college and university engineering students will compete in the first annual Methanol Marathon, a design engineering competition that will give engineering students experience in using a nonpetroleum fuel. Teams were selected to compete in the Marathon by submitting winning proposals that described their innovative approaches for converting a new car to operate on a blend of 85% methanol and 15% hydrocarbons.

The Methanol Marathon will be held April 29–May 3, 1989, under the auspices of the Society of Automotive Engineers (SAE). General Motors Corporation, the primary sponsor of the 1989 event, will provide each of the 15 student teams with certain methanol-compatible components and a new Chevrolet for conversion to methanol fuel. Other sponsors include British Petroleum of America, which will provide the fuel, and Lubrizol, which will furnish a special engine oil. The U.S. and Canadian governments will award $20,000 in cash prizes to Marathon winners. In addition, the two governments will provide $1000 grants to each participating school to help defray conversion costs.

Each of several events that make up the Marathon itself will contribute to the overall scoring. On April 29 at the General Motors Technical Center in Warren, Michigan, each team will make an oral presentation on its conversion approach. Judges will also assess the quality of the conversion itself. Then, after a thorough safety check of each vehicle, tests will be made of vehicle acceleration, noise levels, and exhaust emissions.

On the morning of April 29, following a check of the vehicles' cold starting and driveability, the teams will depart in their cars on the first leg of a 4-day, 900-mile road rally. The rally route will take the teams to Toronto, through Buffalo to several stops on the East Coast, and finally into Washington, D.C. The Sports Car Club of America, with the cooperation of the Canadian Auto Sports Club, will sanction and time the event and staff the rally checkpoints. Fuel economy will be the major scoring component, although the overall performance of each team on the rally course will also be recorded and scored. The finish of the rally will coincide with the 1989 SAE Government/Industry Meeting in Washington. At a special banquet on May 3, high-ranking officials of industry and the U.S. and Canadian governments will present the Methanol awards.

**Fig. 3.6. The Methanol Marathon.**

## 3.3 CONSERVATION SUCCESS STORIES

Figure 3.7 highlights a number of successes of DOE's Conservation programs (U.S. Department of Energy 1987). These successes illustrate the results to date of the public investment in the Conservation program.

Three kinds of successes are included:

- **Completed technology success stories**—completed new technologies that have resulted in nationally significant energy benefits.
- **Program successes**—non-R&D program activities that have resulted in nationally significant energy benefits.
- **Technical successes**—Significant research achievements contributing to technical knowledge and understanding of a topic important to securing future national benefits.

A total of 22 completed technology successes and 13 program successes were identified in a publication titled *Conservation Success Stories* (U.S. Department of Energy 1987). The total federal cost for these 35 projects was $92.3 million; in 1986, the projects resulted in a national annual energy savings of approximately 105 trillion Btu, worth an estimated $350 million at 1986 fuel prices. Additionally, 37 technical successes made significant advancements in the state of the art of energy-using technologies. Some of these may become the subjects of future technology transfer efforts.

ORNL-DWG 88-16701

| PROGRAM OFFICE | COMPLETED TECHNOLOGY SUCCESSES | PROGRAM SUCCESSES | TECHNICAL SUCCESSES |
|---|---|---|---|
| BUILDINGS AND COMMUNITY SYSTEMS | Heat pump water heater<br>High-efficiency refrigerator compressor<br>Low-E window coatings<br>Solid-state ballast | Appliance efficiency test procedures<br>DOE-2<br>Energy Institutes<br>Flame retention head oil burner | Building Energy Data Base (BECA)<br>Daylighting<br>Infiltration model<br>Surface wave lamp |
| TRANSPOR-TATION | Alumina based ceramic<br>Ceramic turbine rotors<br>Gel/Cell lead acid batteries<br>Tensile testing system | Electric vehicle site operations<br>High-Temperature Materials Laboratory | Alternative transportation fuels<br>Low-cost/high-temperature alloy<br>Single Shaft Electric Propulsion (ETX-1)<br>Nonautomotive Stirling engine applications |
| INDUSTRY | Ceramic recuperators<br>Slow speed diesel cogeneration<br>Catalytic distillation<br>Hyperfiltration | Energy Analysis and Diagnostic Centers<br>Boiler workshops | Membrane distillation<br>Brayton cycle solvent recovery<br>Cruciform ceramic tube recuperator<br>Bayonet ceramic tube recuperator |
| ENERGY UTILIZATION RESEARCH | Nickel aluminide alloys<br>RAPRENOx technique<br>Alternator and battery charging system<br>Steam turbine packing ring | Numerical model for a pulse combustor<br>Engine combustion computer models | Base oil separation and characterization<br>Ceramic joining and surface modifications<br>Chromosomal amplification<br>Exfoliated graphite fibers |
| FEDERAL ENERGY MANAGEMENT PROGRAM | | Shared Savings Pilot Demonstration<br>Mobile energy laboratory demonstrations | Energy use metering and analyses<br>Life cycle costing methodology |

**Fig. 3.7. Selected successes of DOE's Conservation program.**

# 4. ALTERNATIVE WAYS OF COMMERCIALIZING CONSERVATION TECHNOLOGIES

## 4.1 SIX ALTERNATIVE STRATEGIES

The Office of Conservation achieves technology transfer by engaging in activities that link Conservation products and processes to private- and public-sector users. These activities are orchestrated by overall strategies or approaches tailored according to the nature of the research result being transferred, the intended audiences, and the primary barriers to utilization. While close cooperation with industry is characteristic of the strategies used by the office, this cooperation can be achieved by many different types of activities involving a wide array of transfer mechanisms (Fig. 4.1)

The following six technology transfer strategies illustrate the range of technology transfer approaches used by the office:

- contracting R&D to industrial partners;
- working with industrial consortia;
- licensing to industry;
- influencing key decision makers;
- working with trade, professional, and regulatory organizations; and
- generating end-user demand.

These strategies are not mutually exclusive. For instance, DOE may support R&D conducted by an industrial consortium that is advised or cofunded by trade and/or professional organizations. Alternatively, DOE may support workshops to inform manufacturers of a new product opportunity that has energy-conservation advantages (i.e., "influencing key decision makers") while at the same time, end-user demand is being generated by informing consumers of the product's advantages. End-user demand is often promoted at the end of subcontracted R&D efforts.

Each of DOE's five Conservation programs emphasizes a different subset of strategies. Because these strategies are "played out" with particular activities, the offices also differ in terms of the mechanisms they typically employ.

Figure 4.2 provides an introduction to the strategies by comparing and contrasting their advantages, disadvantages, and appropriate situations for use. A detailed description of each strategy is then provided. This chapter concludes with a discussion of several more important transfer mechanisms. The use of the technology transfer strategies and mechanism by each Conservation program is the subject of Chap. 5.

### 4.1.1 Contracting R&D to Industrial Partners

Using industry as the research contractor is a common strategy for achieving commercialization. The office often supports R&D by those industrial teams that not only have the necessary technical expertise but also the capability and incentive to manufacture derivative commercial products. With this approach, the firm is given the support to reduce its perceived risk and the incentive it needs to develop and vigorously market a technology. Because the potential manufacturer is an integral part of the development of the technology, the chances for its commercialization are improved.

Sometimes a small level of support to a firm can allow researchers to demonstrate to R&D management that a particular area of research and commercial development is potentially profitable. Cost sharing from the industrial partner is encouraged, both as evidence that the firm is committed to the commercialization process and as a way of enhancing the R&D through private funds.

A common sequence of events is for a national laboratory to issue a request for proposals for prototype development to attract a major manufacturer to share costs. Often, only small manufacturers (or small research firms with minimal manufacturing capabilities) respond. Through a subcontracting arrangement to the

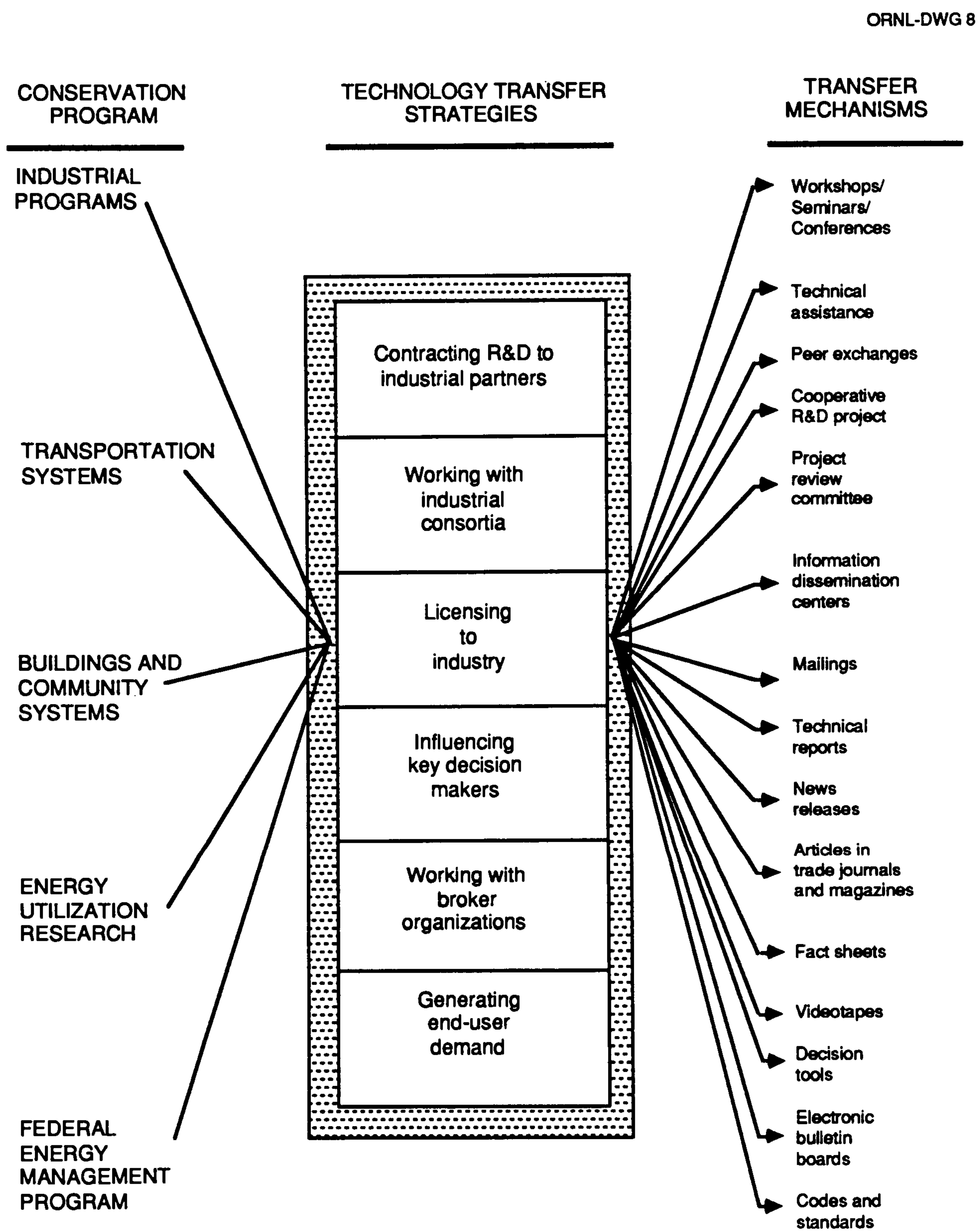


**Fig. 4.1. Conservation programs, technology transfer strategies, and transfer mechanisms.**

| | CONTRACTING R&D TO INDUSTRIAL PARTNERS | WORKING WITH INDUSTRIAL CONSORTIA | LICENSING TO INDUSTRY | INFLUENCING KEY DECISION MAKERS | WORKING WITH BROKER ORGANIZATIONS | GENERATING END-USER DEMAND |
|---|---|---|---|---|---|---|
| ADVANTAGES | •carries technically feasible inventions into commercial production<br>•overcomes "not invented here" syndrome<br>•allows protection of proprietary information<br>•potentially reduces technology transfer costs<br>•enhances resources through cost sharing | •focuses on market needs leading to more transferable technologies<br>•gains access to enhanced resources through sharing of equipment, funds, and expertise<br>•disseminates information quickly to industry | •provides reward for effective technology transfer<br>•allows many firms to benefit when the market is large | •can achieve greater impact than broadcasting untailored information<br>•provides logic for designing specific marketing approaches | •often provides an effective channel for assessing the needs of the industry and sharing Office of Buildings and Community Systems R&D results<br>•can be inexpensive<br>•enhances resources through cost sharing | •consumer education can achieve long-term behavioral change<br>•some consumer education activities are low cost |
| DISADVANTAGES | •may be difficult to choose a partner<br>•risk and equitability problems associated with reliance on a single firm or partner | •may require special organizational units to be established, which may be expensive to coordinate<br>•proprietary interests may discourage the sharing of information<br>•the nonproprietary dissemination of information may discourage product development | •may select inappropriate licensees | •may be expensive to conduct necessary background research<br>•may be expensive to implement | •may be ineffective or inequitable if organization's membership is limited<br>•"vested interests" of the organization may distort or limit information transfer<br>•loss of control over information transfer | •direct market interference can create unintended distortions<br>•some consumer education activities are ineffective<br>•wide variability in effectiveness |
| APPROPRIATE SITUATIONS | •product-oriented R&D<br>•potentially useful at all stages of the R&D process but particularly appropriate during development of basic technology for products and product development | •when a group of firms faces a generic R&D problem critical to their international competitiveness<br>•when the risks and capital requirements are too great for a single firm to "go it alone" | •with spin-off technologies<br>•later stages of technology development<br>•with small or large potential markets | •when specific groups of decision makers hinder diffusion<br>•when R&D findings are technically intricate or difficult to communicate<br>•when R&D findings need to be targeted for use by diverse audience segments | •when an effective communication network already exists within an industry's associations<br>•at all stages of the R&D process, but particularly for long-range, utilization, application, and impacts research<br>•when limited resources are available for technology transfer | •when rapid changes in consumer behavior are required<br>•when products are technically difficult to understand<br>•when actual energy savings are difficult to observe<br>•when R&D relates to utilization, application, or impacts |

**Fig. 4.2. Alternative technology transfer strategies.**

national laboratory, the selected small company is supported (with some cost sharing) to develop a prototype. The national laboratory evaluates the prototype, and either the laboratory or the small firm completes a market study. Field tests and demonstrations are conducted jointly by the laboratory and the small firm.

Normally, the DOE involvement ends at this point. The small firm that developed the prototype begins commercial production. After a few years, the innovation is then added to the product line of one or more major manufacturers through imitation, licensing, or the purchase of patent rights. This sequence of events is illustrated in Fig. 4.3 for the low-E window.

For each of four Conservation innovations that followed this pattern (heat pump water heater, supermarket refrigeration compressor system, low-E window, and solid-state ballast), interviews with industry representatives indicated that the DOE role was significant. Either the technology would not have been developed without DOE support, or at the very least, the pace of technology development, market entry, and market penetration would have been significantly slower (Brown, Berry, and Goel 1988).

## THE COMMERCIALIZATION OF LOW-E WINDOWS

The commercialization of low-E windows occurred through subcontracted R&D. In 1976 DOE initiated a program at Lawrence Berkeley Laboratory (LBL) to research low-E coatings. Windows with low-E coatings offer high energy-savings potential because they admit light and useful solar heat gain but their thermal behavior is similar to that of an insulated wall. In 1976, the principle behind low-E coatings was understood, but no low-E windows were commercially available in the United States.

Several small research firms received DOE subcontracts to investigate suitable coating systems and deposition processes. Extensive communication with key personnel in the window industry and limited market studies were conducted to improve the fit between various low-E coating window designs and the complex structure of the industry. These market studies were important because the coatings were likely to be developed and sold by glass companies or specialized fabricators, while the windows would ultimately be sold to specifiers and homebuilders by window manufacturers, most of whom had limited or no experience with the coating technology.

After several years of DOE research support, one of the small firms developed a coating technology attractive enough to obtain venture capital for construction of their first production facility. By 1980, Southwall Technologies was working closely with several window manufacturers to develop and refine a fabrication technology that incorporated a low-E film in window units.

In the early 1980s, LBL staff gave presentations on the merits of low-E coatings at industry association meetings and trade shows and met privately with research and marketing staffs from a number of major window manufacturers.

A major market breakthrough occurred in 1983 when Cardinal IG (the firm that supplies the sealed insulating glass units for Andersen Corp., the largest window manufacturer in the United States) invested in a large sputtering plant for low-E coatings. After Andersen offered a low-E window, the product gained new acceptability and credibility for consumers, builders, and specifiers. The availability of the Andersen low-E window placed competitive pressure on other window manufacturers. By the mid-1980s, industry investment in production facilities for the new generation of low-E coatings exceeded $150 million, and virtually every major glass and window company offered a low-E product.

Market response to low-E products has been excellent. Industry marketing and sales representatives estimate that 20% of sales will be of low-E windows in 1988. Within 10 years, low-E will likely be the industry standard. Low-E windows can reduce heating, cooling, and lighting requirements in buildings by 20–40%. LBL estimates that annual heating energy savings from the penetration of about 50% of the residential market for new windows would probably exceed $120 million. The cumulative energy savings associated with the estimated sales of low-E windows between 1985 and 1992 could approach 0.1 quad.

**Fig. 4.3. The commercialization of low-E windows.**

DOE had an opportunity to support the development of compact fluorescents with a similar strategy but could not do so because of inadequate funding. The result is foreign domination of the compact fluorescent market. It is likely that a similar loss of the solid state ballast market would have occurred if DOE had not provided R&D support. In the lighting industry, there is little incentive for the major companies to conduct the necessary R&D to develop new technologies, especially if the innovation would require large capital investments. Competitors are likely to duplicate new products at costs lower than those paid by the innovating firm, thereby undermining any advantages.

Using universities as R&D performers has not been a common commercialization route for Conservation programs. The interests of university researchers do not usually extend beyond the exploratory and basic research phases of R&D programs. Universities also tend not to have the close working ties with industry necessary to ensure that a new technology will attract sufficient private-sector interest and funding. The few exceptions, however, are exemplified by the significant achievements of the Georgia Institute of Technology's (GIT's) DOE-funded textile research (Fig. 4.4). GIT's historically strong ties with Georgia's textile industry have been instrumental in the success of this research program.

**SUBCONTRACTS TO A UNIVERSITY**

The textile/carpet industry is one of the top ten energy-intensive industries in the United States. In recent years, it has had to increase production efficiency to maintain international competitiveness. DOE's Office of Industrial Programs has substantially contributed to the industry's improved efficiency through R&D and the facilitation of commercialization. Included in these projects are the following textile innovations that were developed, tested, and/or readied for commercialization through subcontracts with Georgia Institute of Technology (GIT).

1. **Beck Dyeing Modifications** includes three process changes to the conventional bath (i.e., beck) dyeing of textiles and carpet that save energy, water, and materials:

- "bump and run" eliminates at least 83% of the bath boiling time;
- "dye bath" reduces chemical, water, and energy consumption by recycling the spent dye bath after it is reconstituted; and
- "hot pull" eliminates the final rinse step, thus minimizing handling of the spent dye bath and saving water and materials.

DOE funded GIT, which subcontracted with Salem Carpet Company, to demonstrate the modifications. For a total DOE cost of $214,000, the process modifications were proven to be cost-effective. Approximately 70 dye units now use one or more of these modifications, saving 0.25 trillion Btu per year, with 7.6 trillion Btu per year projected for the year 2010.

2. **The Machnozzle,** used in the wet processing of textiles, is a device that eliminates most of the loss of thermal energy to the surrounding environment that occurs with conventional textile drying. It accomplishes this by accelerating high-pressure steam to the speed of sound and shooting it through the fabric, thus, literally blowing the water out of the fabric. The steam loses little of its heat as it passes through the fabric, so it is then used to heat water for other uses in the plant. DOE first contracted GIT to conduct a pilot-scale demonstration of the innovation; it then cost shared with J. P. Stevens and Company to demonstrate the technology on a commercial scale at J. P. Stevens' plant in Clemson, South Carolina.

3. **Solid on Solid Processing** is a textile processing method that DOE is currently funding through a subcontract with GIT. When developed, it is likely to eliminate wet processing of textiles and its inherit energy intensiveness.

**Fig. 4.4. Improving efficiency in the textile industry through subcontracts to a university.**

## 4.1.2 Industrial Consortium Approach

This approach involves DOE managers' and laboratory scientists' working closely with groups of firms to develop a particular innovation or to perform an R&D effort. In a typical consortium arrangement, each company contributes only a portion of the cost of the research but receives information on all work conducted. The consortium may retain patent rights on any new technologies, with member companies usually receiving nonexclusive, royalty-free licenses. Nonparticipating firms may also be licensed, and royalties from them are shared on the basis of annual firm contributions (Johnson and Tornatzky 1981). Known as leveraging, this pooling of small investment justifies high-risk research by minimizing the cost to each member. It also reduces R&D duplication because companies share information on common problems.

According to Siemens (1988), industrial consortia are most appropriate when

- a group of companies faces the same generic technology development problem critical to their international competitiveness,
- the risks and capital requirements are too great for a single company to "go it alone," and
- a national laboratory has strong capabilities that supplement or complement those of industry.

DOE has had limited success with this type of arrangement because of problems of consortia funding and degree of risk (DOE 1988b). An attempt by ORNL to create the Ceramics Advanced Manufacturing Development and Engineering Center (CAMDEC), for instance, has been unsuccessful. As originally envisioned, CAMDEC was to be sponsored and managed by a group of U.S. companies interested in developing advanced ceramic processing and manufacturing technologies. The center was to develop technologies that characterize and control each step of the manufacturing process to ensure the reliable production of advanced ceramic components. The consortium arrangement offered industry a financially leveraged investment, not only through membership cost sharing, but through the cost avoidance achieved from using existing facilities, equipment, and expertise at ORNL (Siemens 1988). While many firms expressed an interest in participating in the consortium, only one firm was able to pay the required fee.

Research and development limited partnerships (RDLPs) provide a special type of consortium arrangement available to the Conservation program. Although there are many variations, the typical RDLP structure includes the three following major components:

- a technology that can be researched and/or developed to provide a return in the commercial marketplace,
- significant equity capital contributed by limited-partner investors to finance the development, and
- royalties on product sales (resulting from R&D) that flow to limited partners in the form of capital gains.

The partnership agreement for an RDLP provides for two types of partners: general and limited. The general partner provides the management for the business, obtains funding, arranges for the necessary research, and either manufactures the new products developed from the research or licenses out the research results. The limited partners are investors in the business but exert no active management.

An RDLP might be structured for a federal laboratory around a nationally recognized institute or center of excellence. In this arrangement, the center provides the partnership with a license to the basic technology. Upon successful completion of the R&D, the partnership would gain ownership of the new development. The rights to the property could then be licensed to a manufacturer for the marketing of the product. Royalties would flow back to the partnership from this commercialization effort.

As one example, Los Alamos National Laboratory is currently involved in an R&D limited partnership. A procedure was invented at Los Alamos by which viruses and bacteria could be quickly identified. A venture capitalist raised

$8.5 million through an R&D limited partnership with Prudential-Bache Securities and gave 50% of the money to the laboratory to develop a commercial prototype. The partnership acquired full ownership of the technology and then granted an exclusive license to a new company. The partnership pays the laboratory for use of its staff during regular hours and hires laboratory scientists as consultants after hours. The arrangement took 2 years and 11 contracts to finalize. The major difficulty was the patent; DOE had to waive its title to the University of California, which operates the laboratory; and in return, the university had to waive its title to the partnership.

### 4.1.3 Licensing to Industry

Licensing technologies developed at national laboratories and universities to industry has increased in frequency as a method of transferring publicly developed R&D. To license a technology and preserve its commercial value, it must first be protected as a patented invention or copyrighted material. Each DOE laboratory conducting conservation research has its own technology transfer program and the capability to license once DOE has granted a patent or copyright waiver.

The choice between exclusive and nonexclusive licensing must be made and appropriate licensee(s) found. Exclusive licensing is often necessary to interest private industry when a technology requires significant additional development before commercial production can begin. It is also appropriate when the market for a technology is small, as was the case with the tensile-testing system described in Fig. 4.5. Nonexclusive licensing is more appropriate when the potential market for a technology is large enough to accommodate many firms or when there are many potential direct or spin-off applications. Both conditions characterize whisker-reinforced ceramics, which were developed with support from the ECUT program and OTS. The ceramics have been licensed by ORNL to several firms (Fig. 4.6).

**TENSILE-TESTING SYSTEM**

The commercialization of the self-aligning tensile-testing system was achieved through an exclusive licensing agreement between a laboratory contractor and a small business.

Because it is difficult to grip and pull ceramic test specimens in a manner that distributes the stress evenly, the source of most data on ceramic strength is bend testing, in which a specimen is bent until it fractures. However, values obtained by bend testing are largely controlled by near-surface properties and flaws rather than by internal tensile stresses. To address these limitations, ORNL developed a system for measuring tensile fatigue and properties of toughened ceramics. The system eliminates fixture-induced bending; its grips and fixtures result in data on the pure tension-yielding strength of specimens in a form more useful to developers of advanced ceramic engines.

The system was developed at ORNL during FY 1985 and was demonstrated at ORNL during FY 1986. In August 1986, Martin Marietta Energy Systems, Inc., signed an exclusive license with Instron Corp. for the tensile-testing system. The company paid a licensing fee and advanced royalties to Martin Marietta Energy Systems, Inc. Royalties will continue to be paid as sales are made. The royalties received from this tensile-testing system will be reinvested in programs for developing and marketing other Martin Marietta Energy Systems, Inc., technologies.

The tensile-testing system has been commercialized and is currently sold on the market as the "Super Grip System." With the advent of ceramic composites and with the known limitations of bend testing, tensile testing offers the promise of new data for research, development, and design of high-tech ceramic materials and composites.

**Fig. 4.5. Commercialization of a tensile-testing system.**

**WHISKER-REINFORCED CERAMICS**

Ceramics comprise a wide variety of materials, some of which have been used since ancient times. Recently, however, ceramics have been used in more complex and sophisticated applications. These advanced materials are made of high-purity compounds that can meet demanding performance criteria. Through developments in many disciplines, the basic knowledge of the processes and mechanisms that control the properties of these materials has expanded rapidly over the past 15 years.

Ceramics offer the potential of high-temperature capability needed for optimum energy efficiency at low cost. Because of this, a major DOE effort was directed at developing tougher and stronger ceramic materials.

Research on whisker-reinforced ceramic composites began with funding from DOE's Energy Conversion and Utilization Technologies program. The Office of Transportation Systems subsequently funded ORNL scientists to work further on the composites, beginning in FY 1983.

The composite that resulted from these efforts consists of an alumina matrix reinforced with microscopic "whiskers" of silicon carbide (SiC), which double the toughness of the normally brittle alumina. The new material is 40% tougher and 25% stronger than nonreinforced ceramics. The microscopic whiskers help the normally brittle alumina resist cracking, in much the same way nails keep boards from being pulled apart. When a crack begins in the matrix, the stronger SiC whiskers bridge the gap and stop the crack's growth.

A nonexclusive licensing approach was used by Martin Marietta Energy Systems, Inc., to commercialize the whisker-toughened ceramic composite developed at ORNL. The first step was for Martin Marietta Energy Systems, Inc., to obtain a patent waiver from DOE, so that an aggressive licensing program could be initiated. The waiver was obtained in 1986.

The ceramic "whiskers" have been licensed to six firms, principally for applications in industrial cutting tools and wear parts. This technology is being marketed commercially by these firms and is expected to have a significant impact on the billion-dollar-a-year cutting-tool industry. Other potential spin-off applications include silicon-chip packaging, containment for radioactive waste, and external heat protection for spacecraft.

**Fig. 4.6. Commercialization of whisker-reinforced ceramics.**

ORNL's licensing approach, described by Soderstrom (1988), may offer new ideas for other laboratories. For instance, under its licensing agreements, the government is allowed to retain a royalty-free, paid-up, nonexclusive license to any federal technology. Licensees are not required to pay royalties on sales of the technology for government use, but they must prove that the price charged for government sales is reduced by at least the amount of the royalty due on a commercial sale.

The licensing policy does not allow a licensee to merely place a technology on the shelf. An action plan for commercial exploitation of the technology must be prepared and implemented before the license is granted. If the licensee does not actively pursue commercialization of the technology, the license may be terminated.

Finally, ORNL requires that products from its licenses, if sold on the U.S. market, must be substantially produced in the United States. Jobs and tax revenues are thereby maximized.

### 4.1.4 Influencing Key Decision Makers

The goal of this strategy is to increase the application and adoption of R&D results by carefully identifying and targeting key industry decision makers who have a strong influence over the future of a technology and its end use. Targeting information and incentives for key decision makers has the potential advantage of greater impact than an untargeted approach.

This strategy involves (1) identifying the key decision makers whose interest in a technology would facilitate its adoption, (2) conducting market research to determine how to make the technology attractive to them, and (3) implementing a technology transfer program aimed at influencing these decision makers. In many industries served by DOE's Conservation program, there are numerous intermediaries who can accelerate an innovation's progress. For instance, in the buildings industry, builders, contractors, architects, engineers, operation and maintenance (O&M) personnel, and many others have some decision-making authority over the promotion, adoption, or use of Conservation technologies.

The Existing Buildings Energy Research Program of OBCS is conducting the background market research necessary to employ this technology transfer strategy. The research results illustrate the complex decision making that influences energy retrofit decisions. As an example, Fig. 4.7 identifies 12 separate decision makers typically involved in retrofitting small apartment complexes. The key decision makers are different for single-family; large-scale, multifamily; commercial; and public housing retrofit projects.

ORNL-DWG 16074

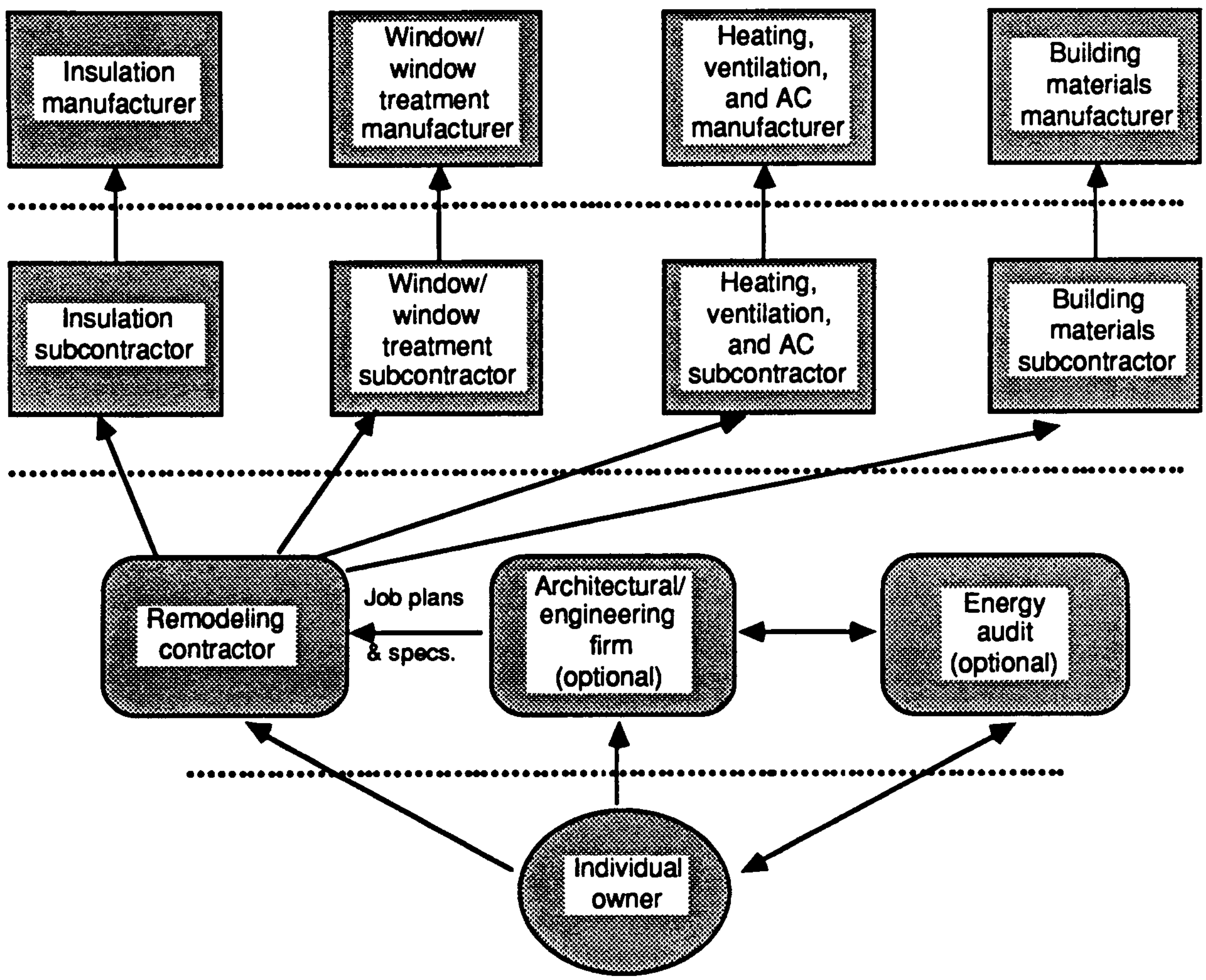


**Fig. 4.7. Decision makers influencing small-scale, multifamily retrofits.** *Source:* Applied Management Sciences, Inc., "Technology Adoption Strategy for DOE's Existing Buildings Program," draft report, Oak Ridge, Tenn., 1988.

Commercialization of the flame-retention-head oil burner provides a vivid example of the effectiveness of targeting key decision makers can be (Fig. 4.8). In this instance, selected outreach and incentives were aimed at fuel oil dealers and service personnel. A consumer outreach program was also part of this successful technology transfer effort.

## 4.1.5 Working With Broker Organizations

This strategy uses trade, professional, and regulatory organizations as "brokers" to carry out the technology transfer process. Because many such organizations have continuing contact with their members, have their members' confidence, and speak their language, they provide DOE with a useful information exchange system. Through this system, user needs can be assessed, innovations evaluated, and commercialization promoted.

Figure 4.9 describes an instance in which DOE's OTS helped retain the viability of compressed natural gas-powered vehicles by working closely with a regulatory organization. Figure 4.10 describes a successful technology transfer effort that benefitted from close collaboration with a trade association.

**FLAME-RETENTION-HEAD OIL BURNER**

The flame-retention-head oil burner (FRHOB) consists of (1) a slotted metal cone that enhances mixing of combustion air with fuel oil and dramatically reduces drafting, and (2) a higher capacity blower. It reduces oil consumption by an average of 18% for boilers and 11% for furnaces and is also inexpensive. The incremental cost to retrofit an oil burner is small ($200–$400).

Although the technology was commercially available as an energy-saving device in the mid-1970s, it had not achieved significant market penetration. By the late 1970s there were a few manufacturers producing the product, but their volumes were small, and there was little awareness of the technology among the public or the industry.

The fuel oil industry is highly fragmented and highly competitive. Prices are set by producers, and dealers take a standard markup for the service provided. Oil producers are only distantly associated with users and have little incentive to pursue fuel oil conservation. Equipment manufacturers producing oil furnaces and boilers also represent a highly competitive and fragmented industry that lacks vertical integration. Service personnel are not technically sophisticated and are generally slow to adopt new technologies.

To assist with the commercialization of this technology, DOE supported three phases of R&D beginning in 1979: laboratory testing, field testing, and a marketing program. Brookhaven National Laboratory supervised a carefully controlled field test to establish and demonstrate the energy-conservation benefit of the technology. Fuel oil dealers were paid to install and maintain the burners as part of this Fuel Oil Marketing Program. A training program for service personnel was also operated in conjunction with the field test.

As part of the marketing program, 70,000 copies of a consumer-oriented information booklet and fact sheet were distributed to the public through state energy offices and other state and local agencies, DOE regional offices, trade organizations, and real estate offices. Northern and northeastern states were the primary target. Information was then picked up by the media, with articles in newspapers and popular magazines.

The DOE program succeeded by generating end-user demand from fuel dealers and consumers. No attempt was made to reach furnace or burner manufacturers.

The FRHOB technology is now accepted as the standard burner technology for residential oil-burning heating systems. The number of high-efficiency FRHOBs in use increased from 100,000 in 1979 to well over 2,000,000 in 1985. With an assumed 12% level of fuel savings over the preexisting technology, an annual energy savings of almost 0.14 quad is projected by the year 2000.

**Fig. 4.8. Commercialization of the flame-retention-head oil burner.**

**WORKING WITH A REGULATORY ORGANIZATION**

Several years ago, the Office of Transportation Systems initiated an effort to define the limiting concentrations of corrosive contaminants in compressed natural gas (CNG) necessary to prevent corrosion damage to vehicle fuel cylinders, thereby minimizing the potential hazards of using CNG as a vehicle fuel. Recently, the National Fire Protection Association (NFPA) proposed to adopt stringent gas-quality standards on CNG vehicular fuel systems as a means of reducing vehicular fire hazards from ruptured CNG containers. Gas industry spokesmen indicated that such standards would require costly measures to clean the pipeline gas and would probably lead to the demise of CNG vehicles. OTS-supported research determined that such stringent standards were unnecessary.

Using data generated from this project, the NFPA Technical Committee on CNG Vehicular Fuel Systems developed a CNG gas-quality standard for recommendation to the NFPA Standards Council. The council took favorable action on the recommendation in April 1987. Thus, the consequences of the more stringent standards initially proposed by NFPA were avoided by the influence of the work from this project.

**Fig. 4.9. Working with a regulatory organization to maintain the viability of compressed natural gas vehicles.**

## 4.1.6 Generating End-User Demand

To promote an innovation, it is often necessary for end-use demand to be stimulated. Normally, this job would be left to the private sector. Under certain circumstances, however, government involvement is desirable. For instance, when a technology is nonproprietary, the private sector lacks any incentive to engage in expensive marketing efforts because competing suppliers of the technology would also benefit from their promotional activities. Frequently, the knowledge embodied in a new development permits other producers to market the same item or a close facsimile very quickly, eroding the market for the original investor. Alternatively, the need for the technology may be so urgent that it is in the public good for the government to accelerate the natural diffusion process.

End-user information programs—including the development of standardized testing procedures, rating systems, and performance standards and guidelines—can help decision makers make more informed choices among energy alternatives, thereby creating demand. Providing adoption incentives and reducing barriers to appropriate use are alternative ways of creating demand. It is necessary to keep in mind, however, that market interference can create unintended distortions, and many information and education programs are questionable in terms of cost effectiveness.

Sometimes the introduction of a new technology hinges on a success story with a prominent user—one whose patronage would be widely considered an important endorsement of a new technology. Public agencies can sometimes play this role in that their use of some new technology is considered a trend-setting event by end users or even other potential manufacturers and sellers. Indeed, some states and counties are known to be particularly innovative, and their technology choices are closely watched. Stimulating adoption by such prominent users is often the best road to success.

The commercialization of the flame-retention-head oil burner (Fig. 4.8) illustrates an effective effort to create consumer demand. IP's commercialization of a new cement grinding technology involved the creation of demand on the part of cement plant personnel—the end users of this technology (Fig 4.11).

## 4.1.7 Summary

The following descriptions characterize common approaches to technology transfer for four types of R&D representing different stages of the innovation time line.

- **Exploratory and Basic Research.** When research is exploratory in nature, no one firm can conduct the research on its own, and the

**UNEQUAL PARALLEL COMPRESSOR SYSTEMS FOR SUPERMARKET REFRIGERATION**

The Office Buildings and Community Systems (OBCS) worked closely with a key trade association in commercializing a highly energy-efficient supermarket refrigeration system. The new technology features unequal parallel compressors, microprocessor suction pressure control, and floating head pressure control. Laboratory testing estimates that the system with R-12 refrigerants consumes 16.6% less energy than the same system operating with mechanical control and ambient subcooling. The payback period is 2 years in large supermarkets.

In 1978, ORNL issued a Request for Proposals and selected Foster-Miller, Inc., as a subcontractor. Under this subcontract, Foster-Miller first performed a market study to help ORNL select the type of new refrigerator technology most likely to have an impact on energy consumption. Foster-Miller then undertook engineering design, prototype development, and laboratory and field testing. Funding from OBCS totaled $1 million, and cost sharing from Friedrich, Inc. (a subcontractor to Foster-Miller), totaled $250,000.

The Energy Committee of the Food Marketing Institute played an important role throughout the project. Its primary functions were to screen and guide technical developments, help identify supermarkets to test the technology, and disseminate information about the project.

Widespread dissemination of the project's results was a critical factor in the success of the project. Five hundred copies of the project report were prepared, and a copy was sent to each major U.S. supermarket chain. Exposure was also provided by articles in key trade magazines. The project made supermarket end users aware of the technology. According to one engineer at Hussman, Inc., "the industry picked up the technology because of the positive evaluation in the ORNL report."

Every major manufacturer now has a version of the system in its product line. The companies that manufacture the technology include the largest manufacturers of supermarket refrigeration systems. In addition, at least one U.S. company is manufacturing the new technology in Europe for European markets.

Through the American Society of Heating, Ventilating and Air-Conditioning Engineers (ASHRAE) journal article and the ASHRAE meetings, DOE's efforts to develop the unequal parallel supermarket refrigeration system appear to have persuaded designers of retail stores and shopping centers to develop variable-speed compressors for both supermarket refrigeration and air conditioning systems in shopping centers. It is likely that variable-speed compressor systems will soon replace the unequal parallel system for supermarket refrigeration because of cost and reliability advantages. DOE can take some credit for the energy savings that will thereby result because of the early role it played in promoting alternative technologies using the capacity modulation principle.

**Fig. 4.10. Commercialization of unequal parallel compressor systems for supermarket refrigeration.**

ultimate applications are uncertain and possibly widespread. Under these conditions, the broad market can be reached through collaboration with trade and professional organizations and industrial consortia and through user facilities, symposia, and technical publishing.

- **Technology Development R&D.** When the R&D is applied and "hardware" oriented, subcontracting to potential manufacturers and technology licensing approaches are most appropriate. Close collaboration with trade and professional organizations may also be helpful.
- **Applied and Information-Based R&D.** When the R&D is applied and information based, broader outreach efforts are desirable, involving trade and professional organizations, education and training programs, guidebooks, trade magazine articles, and workshops.
- **Support for Market Acceptance.** Where efforts are directed toward adoption and use of a fairly mature technology, generating end-user demand and influencing key decision makers are particularly effective. Documentation of performance data and stimulation of private-sector investment (perhaps through licensing) may also be valuable.

Figure 4.12 identifies the innovation stages during which each of the six strategies would appear to be most appropriate.

**CEMENT-GRINDING TECHNOLOGY**

Several years ago, IP identified comminution (pulverization) as a process area with strong potential for energy conservation. Working in conjunction with the Portland Cement Association (PCA) and the Construction Technology Laboratory (CTL), an energy-efficient grinding process was developed that increased cement-particle breakage efficiencies. The process involves

- modification of mill recirculation rates,
- optimized selection of grinding ball size, and
- use of efficient particle-size classifiers.

Greater control of particle sizes resulted in energy savings of up to 39% over conventional cement production and utilization practices.

The cost-shared IP/PCA project developed the technology and documented energy and product quality results. This information was then disseminated to technical personnel at cement plants (the end-users of the technology) through a variety of mechanisms:

- several technical articles describing the new process were included in PCA's *Newsletter*;
- presentations on the technology were made at scheduled meetings of cement technical personnel; and
- IP and PCA developed a bulletin describing the economic and technical benefits of the technology, which was distributed through PCA to the cement industry.

Currently, approximately 40 of the 200 cement plants that can use this process are employing the newer technology. In an industry that is under strong competition from abroad, the energy cost savings make a significant difference in its ability to compete. Projected annual savings in 2010 are 11.1 trillion Btu, which at $5 per million Btu is worth $55.5 million.

**Fig. 4.11. Commercialization of a new cement-grinding technology.**

## 4.2 TECHNOLOGY TRANSFER MECHANISMS

Each of the strategies described previously involves a number of technology transfer mechanisms—activities directed at stimulating use by public- and private-sector audiences. These mechanisms include various types of information transfer, cooperative R&D, and incentives. They have their own characteristic advantages and disadvantages and appropriate situations for use. As with the more general strategies, they also are more or less appropriate at different stages of innovation development (Figs. 4.13 and 4.14). Employing combinations of mechanisms has been found to be most effective. Some of these mechanisms are discussed in more detail here.

### 4.2.1 Industry Participation on Advisory and Review Committees

The current Conservation research program reflects the advice and comments of many public- and private-sector groups. Often this input is achieved through formal advisory and review committees that review Conservation programs and projects on either a regular or an ad hoc basis. This form of private-sector input has resulted in a greater awareness of industry needs and has frequently caused changes in the direction of R&D activities.

While review committees are inexpensive and easy to administer, they are also vulnerable to special-interest pressures and to conflicts of interest. Further, proprietary interests may discourage information sharing, and non-proprietary information exchange may discourage product development. However, in practice these problems do not occur very frequently.

### 4.2.2 Cooperative R&D Projects

Where possible, and especially when research focuses on technology development rather than exploratory R&D, federal funding is used as a means for attracting private-sector cost sharing.

ORNL-DWG 88-16704

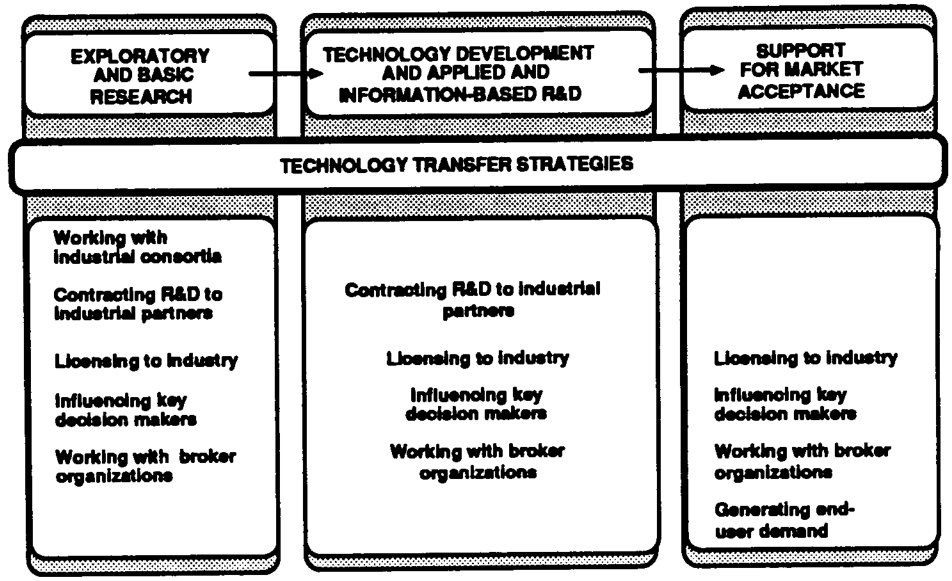


**Fig. 4.12. A time-line perspective to alternative technology transfer strategies.**

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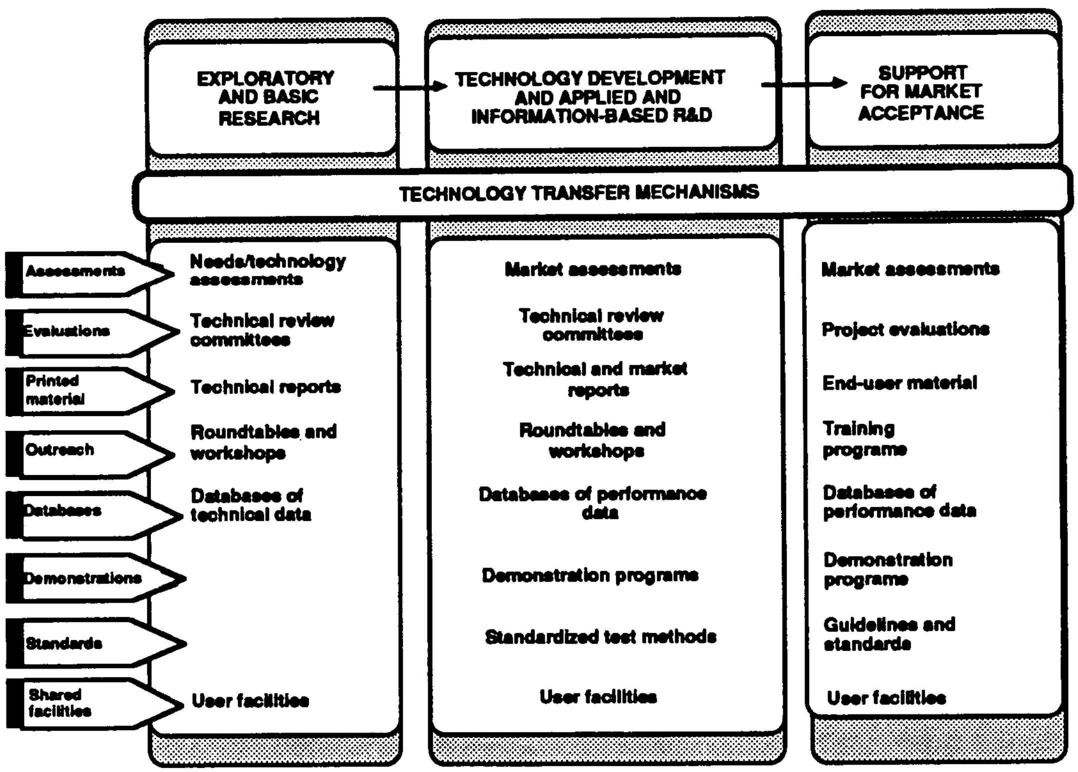


**Fig. 4.13. A time-line perspective to alternative technology transfer mechanisms.**

| MECHANISMS | ADVANTAGES | DISADVANTAGES | APPROPRIATE SITUATION |
|---|---|---|---|
| **WORKSHOPS/ SEMINARS/ CONFERENCES** | •Inexpensive<br>•Assembles key decision makers<br>•Promotes discussion, interaction | •Difficult to follow up | •All stages of technology transfer. The smaller workshops and seminars tend to be most useful for specific topics. Conferences are most useful for subjects with broad appeal. |
| **TECHNICAL ASSISTANCE (e.g., site visits)** | •Direct and immediate<br>•Promotes second-generation technology transfer<br>•Can achieve long-term behavioral change | •Highly selective<br>•Expensive | •Complex information needs to be conveyed, and illustrations and demonstrations are essential |
| **RESEARCHER EXCHANGE** | •Key actors meet, promoting ongoing interaction<br>•Inexpensive<br>•Rapidly accomplished<br>•Technical dialogue can be handled well | •Highly variable payoff | •Key actors need convincing<br>•All stages of technology transfer |
| **COOPERATIVE R&D PROJECT** | •Reduces private-sector risk<br>•Accelerates technology transfer<br>•Gains access to enhanced resources<br>•Overcomes "not invented here" syndrome | •Potential interference with private sector | •Government and industry goals and needs match<br>•Program/technology is feasible, yet untested<br>•When a project is just getting started |
| **PROJECT REVIEW COMMITTEE** | •Promotes government/ industry communication<br>•Provides R&D direction<br>•Inexpensive<br>•Easy to administer<br>•Creates program advocates | •Vulnerable to special interest pressures<br>•Proprietary interests may discourage information sharing<br>•Sharing information may discourage product development<br>•Conflicts of interest may occur | •All stages of technology transfer |

**Fig. 4.14. Technology transfer mechanisms.**

| MECHANISMS | ADVANTAGES | DISADVANTAGES | APPROPRIATE SITUATION |
|---|---|---|---|
| INFORMATION DISSEMINA-TION CENTERS | •Provide responses quickly "on demand"<br>•Referral services may be available<br>•Easy access to information<br>•Tailored responses to specific questions | •Typically passive, must await requests<br>•Quality dependent on information available and staffing | •Addressing broad, large audiences at later stages of technical development |
| MAILINGS (newsletters, fact sheets) | •Effective in generating awareness<br>•Reaches widespread audience or targeted subset<br>•Rapid receipt of message<br>•Information dissemi-nation does not require major user effort | •Communication is not interactive<br>•May not provide desired information<br>•Depth of information covered tends to be limited by the format<br>•Can be easily ignored | •There is a need to generate broad audience awareness quickly |
| TECHNICAL REPORTS | •Tangible, permanent documentation<br>•Can cover complex details necessary for adoption | •No personal contact, which limits impact on behavior | •Addressing scientists and practitioners throughout the stages of technical development |
| NEWS RELEASES | •Reach widespread audience<br>•Inexpensive | •Information likely to be superficial<br>•Limited impact on behavior | •There is a need to generate broad audience quickly |
| ARTICLES IN TRADE JOURNALS AND MAGAZINES | •Tangible, permanent documentation<br>•Can be tailored to an identified audience<br>•Inexpensive | •No personal contact, which limits impact on behvior | •Addressing scientists and practitioners throughout the stages of technical development<br>•When a specific solution has been identified |

**Fig. 4.14. (continued)**

| MECHANISMS | ADVANTAGES | DISADVANTAGES | APPROPRIATE SITUATION |
|---|---|---|---|
| **RADIO AND TELEVISION COVERAGE** | •Reach a wide audience<br>•Rapid receipt of message | •Impact is likely to be of short duration<br>•Expensive<br>•Likely to be superficial<br>•Ineffective in changing strongly held attitudes | •There is a need to generate broad audience awareness |
| **VIDEOTAPES** | •Highly informative<br>•Reach wide audience<br>•Flexible use<br>•Easily edited and updated | •Must establish a distribution network<br>•Expensive | •Complex information needs to be conveyed, and illustrations and demonstrations are essential |
| **DECISION TOOLS** | •Simplifies the communication of complex information | •Necessary computer software may be expensive to develop<br>•Training may be necessary | •Complex information needs to be considered in decision making in order to generate demand for energy-efficient technologies |
| **ELECTRONIC BULLETIN BOARDS** | •Rapid information exchange | •Necessary computer hardware may be expensive to purchase | •An ongoing exchange of technical information is necessary |
| **BANKS OF ENERGY PERFORMANCE DATA** | •Interagency and international capabilities<br>•Easy access to information | •Passive, must await requests<br>•Data can be inaccurate, incomplete, or out of date | •When a technology is at an active R&D stage and further development is dependent on data assimilation and analysis |

**Fig. 4.14. (continued)**

Sometimes cost sharing takes the form of in-kind contributions. For instance, the exchange of equipment and sharing of data among collaborators can significantly reduce the cost of Conservation projects.

## 4.2.3 Consulting and Work for Others

The expertise developed at DOE laboratories with funds from the Office of Conservation is available to U.S. private-sector firms, universities, and other agencies through Work for Others programs.

## 4.2.4 Technical Personnel Exchanges

Laboratory/industry exchanges of personnel and short-term staff visits are often an effective means of transferring R&D results. Many DOE laboratories have personnel exchange or guest worker programs to advance science and further the education of skilled researchers.

Problems occasionally arise when an exchange worker's contribution to an invention causes disputes over who has what rights to the invention. If a substantial investment must be made to bring the invention to market, the invention will normally go unused until the property rights issues are resolved. These problems have been avoided in recent years by defining intellectual property rights in advance of the actual R&D activities.

## 4.2.5 Scientific User Facilities

User facilities are organized specifically to be shared with the entire research community of interest. About 200 scientific user facilities are available for scientific research throughout DOE. In 1986, more than 500 users from 200 companies worked at these facilities (U.S. Department of Energy 1988b).

The Office of Conservation supports a number of such facilities, including

- **The Analysis and Diagnostics Laboratory at Argonne National Laboratory.** This facility is used to examine battery systems of various types and sizes for DOE and private industries. Its activities include (1) experimental evaluations of battery systems to provide an industrial assessment and comparison of the operational status and stage of development of battery systems under simulated application conditions and (2) posttest analysis of battery systems to identify cell failure mechanisms, assess component reliability, determine corrosion reactions, and characterize electrode morphology changes.
- **ORNL's High-Temperature Materials Laboratory (HTML).** This laboratory is a new $19 million research facility located at ORNL. It is designed to help solve high-temperature materials problems that limit the efficiency and reliability of advanced energy conversion systems. Recognizing that the efficiency of heat engines is constrained by the ability of known materials to withstand stress under high temperatures, the Heat Engine Division of DOE's OTS has sponsored HTML. On its own, the ceramics industry could not support the necessary R&D. The industry is composed of small firms with limited R&D budgets and equipment, while R&D on high-temperature materials requires sophisticated and expensive instrumentation.

  One major objective of HTML is the performance of research that will assist U.S. industry in meeting the current challenge of foreign competition in the area of high-temperature materials. Another is to assist in the education and training of materials researchers by the university community. To achieve these goals, HTML provides industry and university researchers with the techniques and instruments needed to solve the complex problems of the high-temperature materials field.

## 4.2.6 Spin-Off Companies

Numerous new companies have been formed to commercialize Conservation technologies. BioDesign Company, for instance, was formed to license computer-aided design graphics for molecular design, a capability developed with support from ECUT's Biocatalysis Program. Technor Corporation was created to commercialize technical applications of RAPRENOx.

In several DOE laboratories, scientists who leave to develop new companies based on DOE technologies are allowed up to 2 years in which they may return to the laboratory if their new business ventures do not succeed.

# 5. THE INDIVIDUALIZED APPROACH OF EACH CONSERVATION PROGRAM

The Office of Conservation's technology transfer challenge is complicated by the diverse nature of its R&D, the wide range of end-use audiences, and the complex of manufacturers and distributors that deliver conservation technologies to their ultimate users. This diversity necessitates a technology transfer approach that can be tailored to meet the particular needs of different programs. The result is that each of the Conservation offices emphasizes different R&D performers (Fig. 5.1), different R&D partners (Fig. 5.2), and different technology transfer strategies (Fig. 5.3).

## 5.1 INDUSTRIAL PROGRAMS

The main principle applied to successfully implementing IP technologies is to work closely with the potential end users for each technology, thereby generating end-user demand. The program's primary end users are process users, manufacturers, and researchers.

Contracting R&D to industrial partners is often a part of this collaborative approach. More than one-half of IP's R&D is performed by industry contractors, and less than one-third is performed at national laboratories (Fig. 5.1). Cost-shared contracts with industry are the mode. When technologies developed by IP are likely to result in an energy-saving product, cost-shared contracts with manufacturers are often initiated to develop a fully engineered, fully evaluated technology. When a successful process technology is developed with IP funding, cost-shared contracts are sometimes let to one or more process users to demonstrate the technology over an extended period, at full-scale implementation.

Economic feasibility is a critical consideration in the IP technology transfer strategy. A technology is considered to be economical if it offers potential users a payback period of less than 3 years. Technologies are considered to be "near term" if the research results due within the next 18 months will determine whether or not the technology is economically attractive. The near-term, economically attractive technologies are the main concern of IP's technology transfer.

The responsibility for transferring a technology may rest with either the technology developer, IP's main field operation [Idaho National Engineering Laboratory (INEL)], or DOE's IP Headquarters. The preferred method is for the developer to market the technology; sometimes this is not feasible, however, because the developer does not have marketing, manufacturing, or distribution capabilities. When INEL has worked closely with the developer of an IP technology, INEL may be best suited to perform the technology transfer. For those technologies in which Headquarters program managers have been key participants, a Headquarters-based technology transfer effort may be most appropriate.

Regular technology transfer reviews of the status of all near-term IP projects are conducted about once a year. These reviews provide an assessment of the adequacy of each project's technology transfer activities and serve as the basis for technology transfer planning efforts. A sophisticated database system of industry contacts has also been developed by IP to directly target audiences for technical publications, workshops, and seminars.

Another interesting aspect of the IP program is the continued tracking of the implementation of IP-developed technologies. With assistance from Pacific Northwest Laboratories and in conjunction with manufacturers and vendors of IP-developed technology, an actual count of the number of units operating and their related energy savings is conducted. For the 25 successfully completed technologies currently being tracked, over 40 trillion Btu are saved annually. This savings represents a value of over $153 million per year.

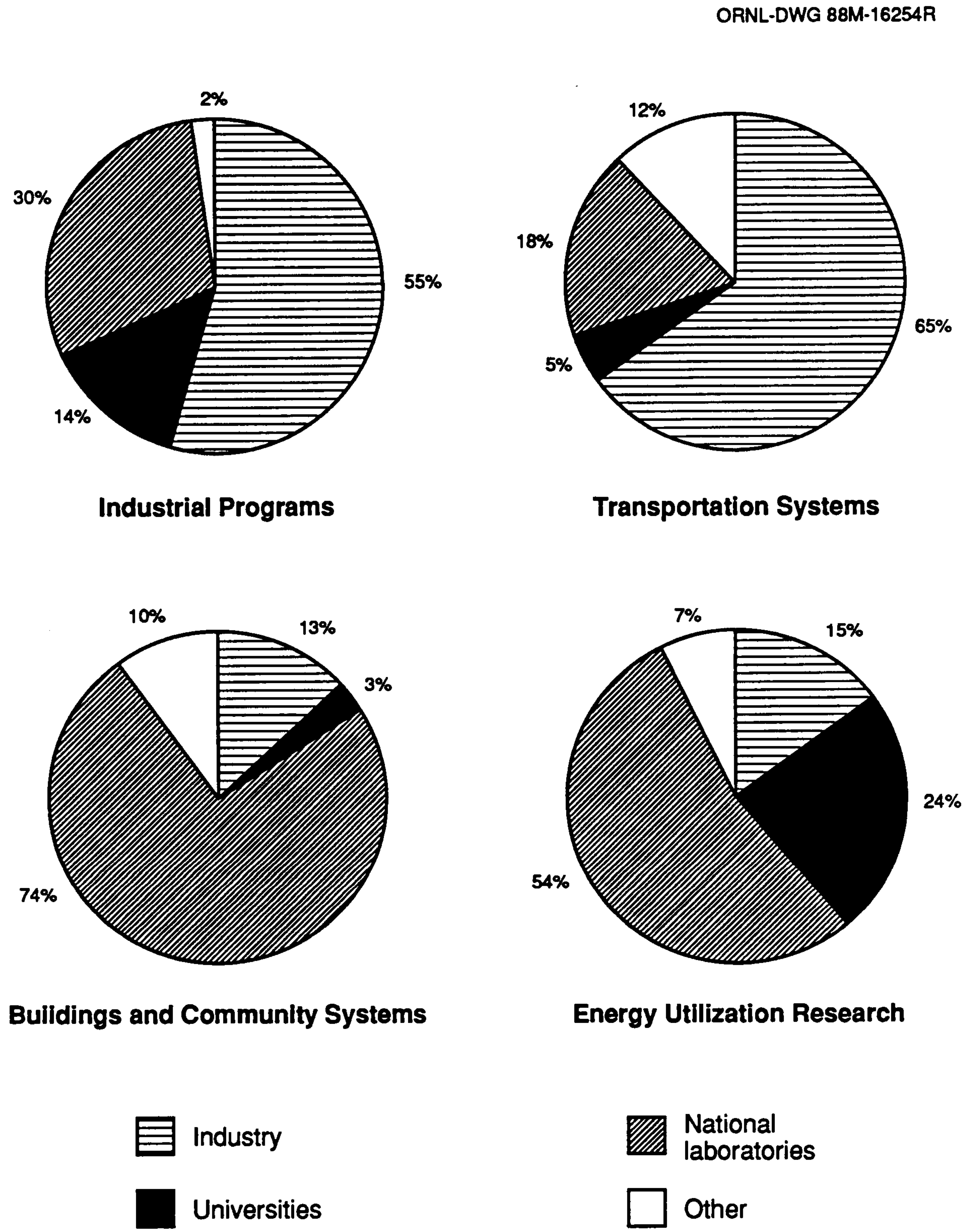


**Fig. 5.1. The R&D performers of different Conservation offices in FY 1988.**

ORNL-DWG 88M-16255R

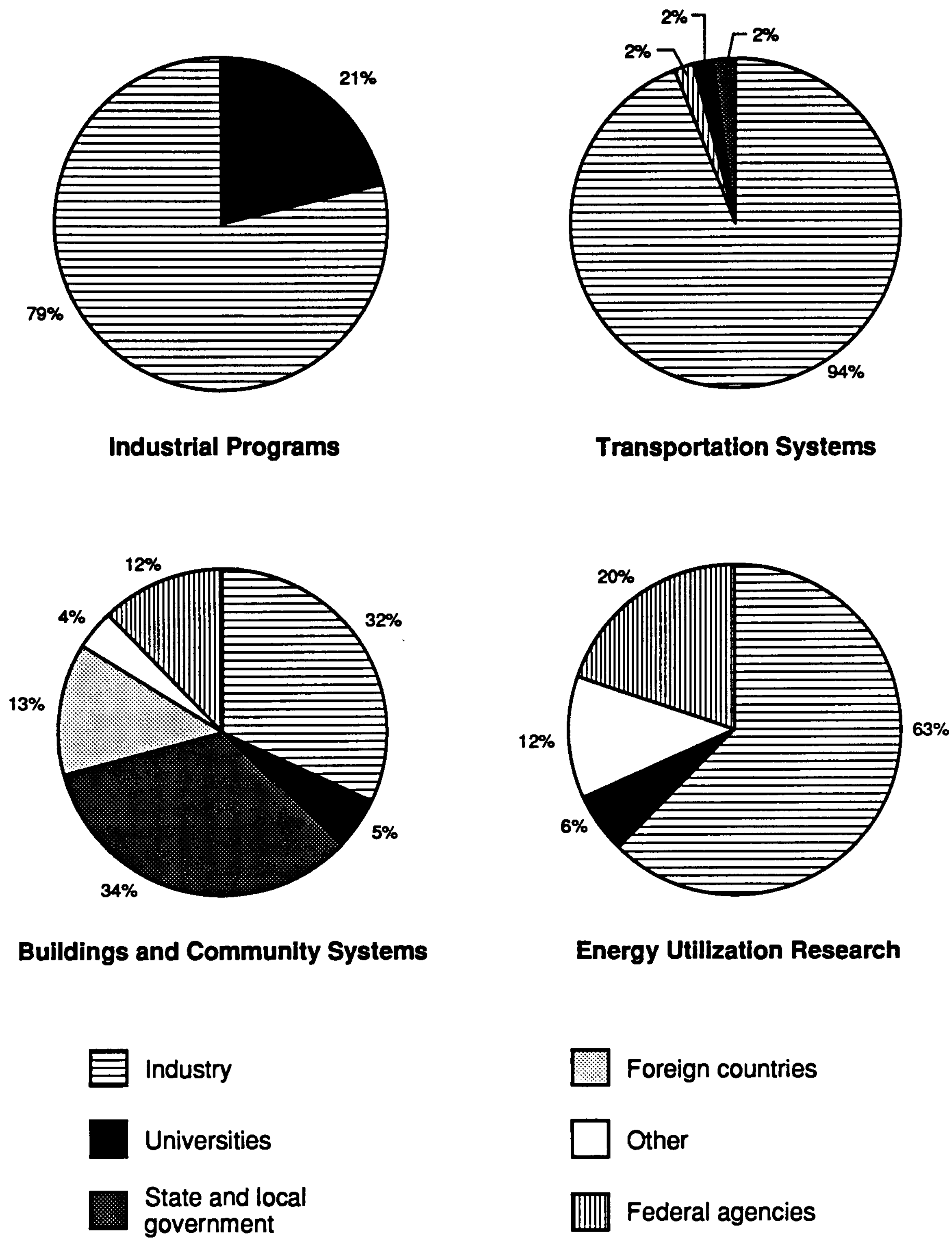


**Fig. 5.2. Sources of cost sharing for different Conservation offices in FY 1988.**

## 5.2 TRANSPORTATION SYSTEMS

The technology transfer strategy of OTS is to contract R&D directly with those industrial teams that not only have the necessary R&D expertise but also the capability to manufacture derivative commercial products if they determine it profitable to do so. Because the potential manufacturer's input is an integral part of the development of the technology, the chances for its commercialization are enhanced. Industry performs a larger proportion (65%) of OTS's R&D, and it contributes more in the form of cost sharing than any other Conservation office (Figs. 5.1 and 5.2).

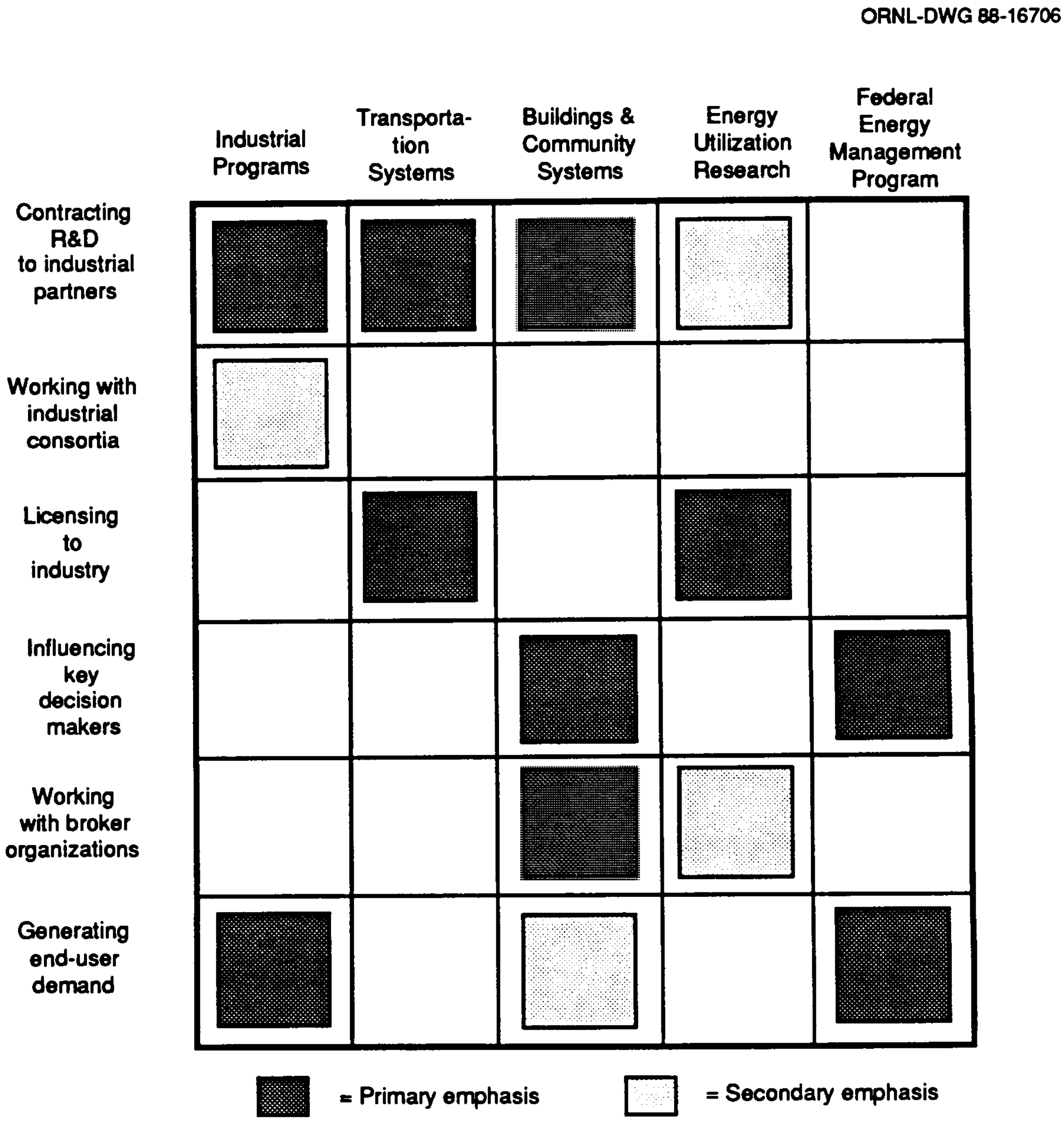


**Fig. 5.3. The technology transfer emphasis of each Conservation program.**

The strategy involves a series of steps (DOE 1988a):

- Specific technology needs are identified in concert with industry through group and individual meetings with representatives of engine, vehicle, parts, and fuel suppliers.
- The petroleum savings and other benefits from specific technology options are estimated and reviewed.
- With industry participation, the technology options are placed in priority order. Care is taken to avoid any duplication of R&D that might be conducted by industry on its own.
- Contracts are made with industry participants and research institutions to conduct R&D. Cost sharing is achieved to the maximum extent possible.
- Annual contractor coordination meetings and frequent program review meetings are held to check on the success of the R&D efforts.
- The results of R&D are transferred to the user community through meetings and reports. In most cases, the ultimate user of the technology was a cost-shared participant in the R&D, and this ensures that the technology transfer is successful.

This strategy is effective partly because of the well-defined audiences the transportation program addresses: the major U.S. automobile, battery, electronic component, and ceramic materials manufacturers. Users such as utilities, fleet operators, government decision makers, and motorists are considered secondary audiences. Automotive manufacturers in the United States are highly risk averse. Their R&D spending is directed at near-term design improvements to enhance customer satisfaction and to meet federal regulations on fuel efficiency and environmental quality. Billions of dollars are required to move major new technologies from the laboratory to preproduction, demonstration, production engineering, and retooling.

An emerging trend in the U.S. automotive industry is for manufacturers to conceptualize new vehicles and for suppliers to then design, build, and deliver components and subsystems that are subsequently assembled by the manufacturer. For this reason, the role of the supplier is becoming more critical. These secondary audiences such as the engine, battery, electronics, and ceramics manufacturers thereby offer an alternative for influencing industry decision makers. Licensing the results of national laboratory R&D to these audiences and to manufacturers of spin-off applications has been another route to successful OTS technology transfer.

Niche markets hold great potential for the commercial introduction of OTS technologies. To be successful, a niche market must provide a manufacturer with a sector in which new products can be sold without sacrificing sales of a product already on the market. To be appealing for commercial development, a product must indicate the potential for an expanded market. One of the larger niche markets (for the electric vehicle) involves a U.S. stock of approximately 2.2 million vans.

## 5.3 BUILDINGS AND COMMUNITY SYSTEMS

The highly fragmented nature of the buildings industry distinguishes it from the industrial and transportation sectors. Over 28,000 homebuilders, more than 1,000 commercial builders, thousands of manufacturers of building materials and components, and hundreds of architectural engineering firms currently operate in the United States. This fragmentation is further exacerbated by

- the limited use of mass production and standardized practices;
- the numerous decision makers involved in a single construction project and the ad hoc nature of project teams; and
- the lack of coordination among building sectors (commercial, residential, and industrial).

It is therefore difficult for the industry to fund the technology research and to exchange information about new technologies. Because of this fragmentation, trade and professional organizations are important in the industry and in the technology transfer program of OBCS. National laboratories are the dominant R&D performers, representing 74% of the OBCS budget (Fig. 5.1), and cost sharing comes from a variety of sources (Fig. 5.2).

Because numerous entities influence decisions in the buildings industry, OBCS also focuses its technology transfer efforts on a variety of key decision makers—architects, engineers, builders, O&M personnel, and others who often decide how energy efficient a building and its equipment will be, with little direction from the eventual building owners or occupants. Exclusion of the owner/occupant from such decisions encourages energy inefficiency and higher life cycle costs. To reach these key decision makers, OBCS has initiated an active outreach effort to place articles on its R&D findings in the trade press. In the past several years, articles on OBCS-supported technologies have appeared in magazines such as

- *HVAC Product News*
- *Air Conditioning, Heating & Refrigeration News;*
- *Appliance Magazine;*
- *Building Design and Construction ;*
- *Roofing, Siding, Insulation Magazine;*
- *The Construction Specifier;*
- *Energy Conservation Digest;*
- *Heating, Piping, and Air Conditioning Magazine;*
- *Professional Builder;*
- *Architectural Technology;*
- *Home Energy;* and
- *Decorating Remodeling.*

## 5.4 ENERGY UTILIZATION RESEARCH

EUR supports programs that represent very different approaches to technology transfer. The ECUT Program involves

- transfer of basic scientific technical accomplishments [from the National Science Foundation (NSF), DOE/Basic Energy Sciences (BES), universities, etc.] into the ECUT Program so that newly acquired knowledge can be applied to mitigate or solve critical technical barriers;
- transfer of ECUT technical accomplishments to the DOE end-use Conservation programs or private sector for development beyond the defined ECUT role;
- support for research conducted primarily at national laboratories and universities to address existing technical problems (Fig. 5.1);
- feedback of information on the usefulness of the research results or definition of new problem areas; and
- feedback to the basic scientists of research needs defined from the critical technical barriers.

Technology transfer is an integral part of the planning process at the program and project levels as well as of R&D.

- Technology needs and areas of R&D are defined and obtained from knowledgeable experts in the industrial and academic communities, national laboratories, and various R&D programs.
- ECUT research is coordinated with other DOE end-use offices to discuss areas where ECUT research will be directly beneficial to existing R&D programs or where critical barriers are identified for ECUT-directed research focus.
- Where possible, industry participation and cost sharing in R&D is accommodated through cooperative research groups.

Guidance and Evaluation Panels have been established specifically to review project plans with respect to their technical content, their relationship to private-sector research, the appropriateness of government participation, and the possibility of private-sector interest in expanding upon research results. In addition, panels of government, industry, and university advisors provide guidance and evaluation of ECUT R&D activities, while the *ECUT Program Bulletin*, technical papers, workshops, and symposia are used for widespread distribution of R&D results to researchers and potential end users in a variety of fields.

Licensing technologies developed by national laboratories to industrial users has been a successful technology transfer strategy for ECUT. Given the generic nature of ECUT's research problems, contracting R&D to industry has not been a widely used approach.

ICP and ERIP have particularly strong commercialization thrusts. Market penetration of ERIP technologies is enhanced through a strong emphasis on commercialization education and technical assistance. ICP relies heavily upon innovative concepts fairs to bring technology seekers together with technology sellers.

## 5.5 FEDERAL ENERGY MANAGEMENT PROGRAM

Efficient energy management by federal agencies is often hampered by factors such as institutional arrangements and procedures; regulatory constraints; lack of market-type incentives; and the operational imperatives of individual agencies, including internal competition for limited funds. FEMP has developed an ambitious 5-year plan that addresses these barriers with a strong portfolio of technology transfer activities.

To facilitate improvement of energy management practices and decision making among federal agencies, the FEMP office strategies include

- identifying key energy managers in federal facilities and ensuring that they receive the information they need to make wiser choices in energy use and management and
- promoting effective energy management practices through training, guides, and improved networks for information exchange.

To encourage the implementation of energy-saving technologies at federal facilities, FEMP office strategies include

- developing and improving tools to identify energy-saving opportunities,
- facilitating innovative financing approaches, and
- coordinating the development of policies that will reduce constraints to implementation.

# 6. CONCLUSIONS

This report has documented some of the significant commercial innovations that have benefitted from DOE's Conservation program and has described the program's sound approach to the technology transfer process, relying on close interactions with industry. Available evidence of the effectiveness of this approach is somewhat fragmented and anecdotal but nonetheless persuasive. In addition to the examples of successfully transferred technologies detailed here and elsewhere, various program statistics document the effectiveness of the effort.

- The Conservation office generated $73 million in cost sharing during FY 1988, indicating a strong interest by industry in the research being conducted and the technologies being developed.
- Thirty-five Conservation projects have resulted in a national annual energy savings of more than 100 trillion Btu, worth an estimated $350 million at 1986 fuel prices.
- Approximately one-fourth of the inventions supported by ERIP prior to FY 1987 have entered the market, generating total cumulative sales of nearly $300 million, compared with cumulative program appropriations of $44 million over the same period.

The close industry cooperation that characterizes the office's technology transfer approach is achieved by many different strategies and activities that vary markedly across individual Conservation programs. Some of the logic underlying this diversity is apparent when the types of R&D and audiences targeted by each of the end-use Conservation programs are considered.

The IP R&D effort focuses on more mature technologies than the other end-use offices do, and its major audiences (the end users of its technologies—process users and manufacturers) tend to be easily targeted. As a result, IP is able to focus primarily on generating end-user demand, a strategy that is often coupled with cost-shared contracting with potential users. The cement-grinding and textile technologies described in this report exemplify the IP approach.

At the other extreme of the R&D spectrum, a large percentage of the OTS budget is devoted to exploratory and basic research. Its primary end users (the major automotive manufacturers) are even smaller in number than those of IP. As a result, OTS relies on contracting its R&D to these industrial partners. Licensing strategies are also used; they have been an effective way of capitalizing on the spin-off applications emerging from research. The application of whisker-reinforced ceramics in the manufacture of cutting tools, described in this report, provides an example.

While the OBCS program is intermediate in terms of its emphasis on generic vs applied R&D, it has the most fragmented audiences of the three end-use programs. Many different strategies are therefore used to reach the program's numerous potential beneficiaries. Trade, professional, and regulatory organizations are employed as technology and information brokers, and key decision makers are targeted as influential points of contact. Contracting with industry has also been a notable path to commercially successful technologies, as in the case of low-E windows.

Thus, what might appear to be a confusing array of technology transfer activities actually represents a logical and effective solution to the technologies transfer problems faced by each Conservation program.

# 7. REFERENCES


Bozeman, B., and M. Fellows 1988. "Technology Transfer at the U.S. National Laboratories," *Evaluation and Program Planning* 11: 65–75.

Brown, M. A., et al. 1986. *Technology Transfer for DOE's Office of Buildings and Community Systems: Assessment and Strategies*, ORNL/CON-202, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Brown, M. A., L. G. Berry, and R. K. Goel 1988. *Commercializing Government-Sponsored Innovations: Lessons Learned from Seven Successful Case Studies*, ORNL/CON-275, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Brown, M. A., and S. A. Snell 1988. *The Energy-Related Inventions Program: An Assessment of Recent Commercial Progress*, ORNL/CON-252, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Easingwood, C. J. 1988. "Product Lifecycle Patterns for New Industrial Products," *R&D Management* 18: 23–31.

Energy Research Advisory Board 1988a. *R&D Initiatives for Energy Competitiveness*, DOE/S-0061, U.S. Department of Energy, Washington, D.C.

Energy Research Advisory Board 1988b. *Research and Technology Utilization*, DOE/S-0067, U.S. Department of Energy, Washington, D.C.

Glaser, E. M., H. H. Abelson, and K. N. Garrison 1983. *Putting Knowledge to Use*, Jossey-Bass Publishers, San Francisco.

Myers, S., and D. G. Marquis 1969. *Successful Industrial Innovations: A Study of Factors Underlying Innovations in Selected Firms*, NSF 69-17, National Science Foundation, Washington, D.C.

President's Commission on Industrial Competitiveness 1985. *Global Competition: The New Reality*, Vol. 1, U.S. Government Printing Office, Washington, D.C.

Roberts, E. B., and A. L. Frohman March/April 1979. "Strategies for Improving Research Utilization," *Technology Review:* 33–39.

Siemens, W. 1988. "Transferring ORNL Technology: Industrial R&D Consortia," *Oak Ridge National Laboratory Review* 1: 12–17.

Soderstrom, E. J. 1988. "Transferring ORNL Technology: A New Licensing Approach," *Oak Ridge National Laboratory Review* 1: 4–9.

U.S. Department of Energy, Office of Conservation 1987. *Conservation Success Stories*, U.S. Department of Energy, Washington, D.C.

U.S. Department of Energy 1988a. *Energy Conservation Multi-Year Plan, 1990–1994*, U.S. Department of Energy, Washington, D.C.

U.S. Department of Energy 1988b. *Technology '87, U.S. Department of Energy R&D Laboratory Technology Transfer Program*, DOE/ER-0355, U.S. Department of Energy, Washington, D.C.

U.S. Department of Energy 1988c. *U.S. Department of Energy, Technology Transfer Summary*, draft report dated July.

U.S. General Accounting Office 1988. *Technology Transfer: Constraints Perceived by Federal Laboratory and Agency Officials*, U.S. General Accounting Office, Gaithersburg, Md.

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