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The Technology Transfer Process

Background for the U.S. National Energy Strategy

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THE TECHNOLOGY TRANSFER PROCESS

Background for the U.S. National Energy Strategy

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EXECUTIVE SUMMARY

This paper describes the objectives, strategies, and mechanisms used by the U.S. Department of Energy (DOE), other government and private technology development organizations in their technology transfer programs. Its scope is limited to listing the technology transfer mechanisms and defining the situations when these particular mechanisms are most effective. In this paper, the specific mechanisms for transferring technology, and the advantages and disadvantages of each are listed based on federal and industrial experiences in using these mechanisms. In addition, several case studies illustrating how technology transfer strategies which use multiple mechanisms have been executed successfully in the past are also included. The conclusions of this paper support those reported by the Energy Research Advisory Board (ERAB) in 1988.

Technology transfer is defined for the purposes of this report as the process by which technology, knowledge, and/or information developed in one organization, in one area, or for one purpose is applied and utilized in another organization, in another area, or for another purpose. The end user may be the public, industry, another federal laboratory, or any other technology developer. Technology information can be a simple energy conservation practice for public use, data bases, a patent of an invention, a report on the properties of a magnetic field, an improved industrial process, or a new procedure for handling a hazardous material. The mechanisms that developers throughout government and industry use to transfer technology can be grouped into eight broad categories: advisory groups, research collaboration, personnel exchanges, technical assistance, licensing, spinoff companies, information dissemination, and education. Successful strategies usually are combinations of several or, possibly, all of these mechanisms.

While a carefully planned strategy for using the many mechanisms available to the technology-developing organization is crucial to successful technology transfer, the transfer of technical information does not ensure a technology's application. Strategies that use mechanisms that encourage feedback are the most successful. The timing stage of the research in which a mechanism is used is also crucial. For example, advisory groups with members from industry are most appropriate for applied, development, or product improvement research and should be used early in the development schedule for any research effort. On the other hand, workshops/seminars/ conferences are most advantageous when research results are available.

Some technologies are identified as potential commercial successes and are transferred to the private sector early in the development process; other technologies are not transferred until they are fully developed and tested. Mechanisms that provide feedback from the end user to the developer, such as advisory groups with potential users as members, tend to be effective ways to stimulate transfer and technology utilization.

Targeting the audience for any technology transfer effort increases the efficiency of the effort. User facilities are an example of one-on-one transfer of technical information to a targeted group of technical people working in a related field. Technical reports and news releases when disseminated to a targeted group--industrial decision makers, engineers or trade association representatives--can also be a desirable means of technology transfer.

Timing, how quickly an application can occur, is critical to the success of a technology transfer mechanism. Energy price changes can result in competing technologies being introduced into the market during the typically long period between concept development and a market-ready product. Therefore, expedient completion of research, patenting, licensing, etc., is vital to the overall success.

A significant portion of the technology developed under DOE sponsorship is designed for use by industry and consumers based on marketplace choices. This presents a more challenging management problem than that faced by the Department of Defense or parts of National Aeronautics and Space Administration's space program, which themselves are end users of much of the technology they develop. Successful technology transfer from these agencies is best described as spinoffs. Technology developments sponsored by regulatory organizations such as the Environmental Protection Agency will usually find their markets as a result of regulations requiring the adoption of specific technologies.

Many legal, institutional, and cultural barriers hinder successful transfer. The role of the technology's champion, frequently not the original developer, is important in overcoming the barriers to transferring the technology to the end user. Many people with experience in the process say that technology transfer requires repeated face-to-face communication. Effective transfer involves feedback from people dealing with people, not just publishing reports.

Evaluating the success or failure of technology transfer processes is difficult. The processes must be evaluated in terms of their original objective. For those with market penetration as their objective, tabulating the number of licenses or number of spinoff companies is a measure of their success. However, for those with data dissemination as their objective, quantifying success is more difficult. This difficulty has inhibited developers from documenting failures as well as success, thus eliminating a valuable source of information on the relative merits of processes.

CONCLUSIONS

The ERAB (1988) study focused on the institutional issues involved in the technology transfer process. Information presented in this report confirms the findings of the ERAB board. However, the focus of our study is on structural issues, such as the definition of technology transfer, mechanisms, strategies as well as illustrating when various mechanisms and strategies are most appropriate. The following is a summary of those findings:

- Successful technology transfer results when strategies are designed to use a variety of mechanisms, especially those mechanisms that have a feedback element. Personal contact is an essential element in transferring complex scientific knowledge, introducing a new product into the market, enhancing user acceptance and encouraging spinoffs.

- The technology "champion" cannot be overvalued. All technologies must overcome many barriers before completing their objective. Even when a technology is transferred, it will need a "champion" in the new organization.

- A good technology transfer strategy shortens the time and minimizes the information loss associated with technology transfer.

- Separating the performance of a technology from the performance of its technology transfer program is difficult. A technology transfer program must be judged in terms of its original objective. Sometimes the technology itself is so developed that the technology transfer strategy can only marginally affect its rapid acceptance. Sometimes a technology is so undeveloped that the best prepared technology transfer strategy cannot affect its rejection.

- Further research, including documentation of failures, would increase understanding of the role of mechanisms, strategies, and timing. The lack of documentation on failures has led to a major loss of historical data, from which valuable lessons could be learned.

Although end-user feedback is not a transfer mechanism, it assures an earlier transfer to the end-user as well as increases the probability of the end-user transfer occurring at all. The earlier transfer will clearly improve the competitiveness of U.S. industry and benefit the public as well.

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1.0 INTRODUCTION

This paper describes the objectives, strategies, and mechanisms used by the U.S. Department of Energy (DOE), its laboratories, other government and private technology development organizations in their technology transfer programs. Its scope is limited to listing the technology transfer mechanisms and defining the situations when these particular mechanisms are most effective. In this paper, the specific mechanisms for transferring technology, and the advantages and disadvantages of each are listed based on federal laboratories' and industry's experiences in using these mechanisms. In addition, several case studies illustrating how technology transfer strategies using multiple mechanisms have been executed successfully. The conclusions of this paper support those reported by the Energy Research Advisory Board (ERAB) in 1988.

DEFINITION OF TECHNOLOGY TRANSFER

Several organizations have defined technology transfer to meet their needs. A definition that frequently has been cited in government reports and the definition used in this report is ". . . the process by which technology, knowledge, and/or information developed in one organization, in one area, or for one purpose is applied and utilized in another organization, in another area, or for another purpose . . . ." (Congressional Research Service 1988). The end user organization may be the public, industry, another federal laboratory, or any other technology developer.

The term "base technology" is defined as the technology developed for the end use planned by technology-development program managers and "spinoff technology" as the technology application that results when an innovative researcher identifies a potential use of the base technology in an application not foreseen by the program managers.

The results of the technology transfer activity can differ depending on the particular situation. In some instances, technology transfer can result in the actual licensing and commercial application of a technology; in other instances it can simply result in the transfer of information or knowledge from a scientist in a federal laboratory to a person in the private sector.

The technology to be transferred is defined broadly as know-how that includes one of three components: 1) product technology, 2) process technology (including standards and practices), and 3) management technology (Capon and Glazer 1987). Thus, in many cases research may not result in the production of a physical product but could result in a new standard or practice that can be used in industry.

To assist in defining this process, the left side of Figure 1 presents the idealized technology development sequence leading to commercial application of a new idea:

- basic research: discover new idea
- exploratory research: determine scientific applications of a new idea
- applied research: determine technical feasibility for a specific application

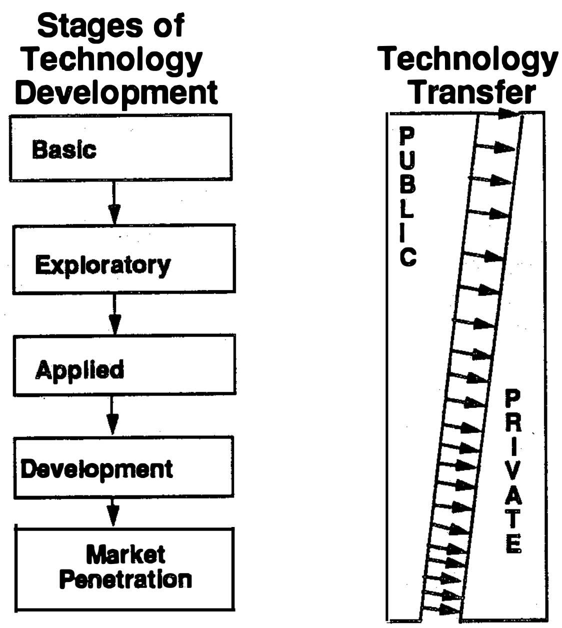

Figure 1. Federal Technology Development and Transfer

- development research: develop and test integrated systems
- market penetration: demonstrate technology and economic feasibility and redesign to market needs

These stages represent the classical path that a technology will take to the marketplace. Technology transfer occurs between each stage of development as information is passed from one organization to another. Technology transfer programs attempt to assist the information transfer process by selecting and combining mechanisms that will help to ensure that the appropriate individuals/organizations receive technology information in a timely manner. The recipients of this information are the technology end-users.

At some point in the federal technology development process, the ownership of rights in the technology is transferred from the public to the private sector, as illustrated on the right side of Figure 1. Technology development continues to occur after the transfer, but it now becomes the responsibility of the private sector, therefore reducing public sector expenses.

Some technologies are identified as potential commercial successes and are transferred to the private sector early in the development process. Other technologies are not transferred until they are fully developed and tested. Ownership transfer is a process that takes time and requires the flow of technical information from the public sector as well as feedback from the private sector on market conditions and needs. Mechanisms that provide this feedback, such as advisory groups with potential end-users as members, tend to be effective ways to stimulate ownership transfer and technology utilization.

A significant portion of the technology developed under DOE sponsorship is designed for use by industry and consumers based on marketplace choices. This presents a more challenging management problem than that faced by the Department of Defense or parts of National Aeronautics and Space Administration's space program, which themselves are end users of much of the technology they develop. Successful technology transfer from these agencies is best described as spinoffs. Technology developments sponsored by regulatory organizations such as the Environmental Protection Agency will usually find their markets as a result of regulations requiring the adoption of specific technologies. DOE's most successful programs have included both market feedback mechanisms and a sound technology transfer strategy.

BARRIERS TO TECHNOLOGY TRANSFER

Several legislative and other proposals have been enacted to remove many of the institutional barriers to technology transfer. The Stevenson-Wydler Act of 1980 made technology transfer a mission of federal laboratories. The Act also required that 0.5% of R&D budgets be allocated to this activity and that all federal laboratories with more than 200 professional employees establish an office of technology transfer to coordinate these efforts.

The Bayh-Dole Act (1980, amended in 1984) allows certain nonprofit and small business to acquire title to government-funded inventions, so such contractors may commercialize the technologies they develop. In addition, DOE required each laboratory to develop an awards program for its employees to provide individual incentives to promote technology transfer.

The 1986 amendment to the Stevenson-Wydler Act permitted government-operated laboratories to enter directly into cooperative agreements with industry and to license patents to cost-sharing sponsors of such agreements. This amendment also requires that employees/inventors share in royalties collected on patent licenses.

DOE has supported various technology transfer initiatives to enhance use of DOE-funded technology through use of cost-shared cooperative agreements and through various patent waivers, copyright of software, and other intellectual property actions to transfer commercial rights to the private sector.

Despite the removal of some of these institutional barriers, other impediments hinder the technology transfer process not only to industry but to other technology end-users. Among these impediments are issues related to access to information, cultural/perceptual differences between the laboratories and the private sector, and changing market conditions. Each of these is discussed below.

Information Access

To facilitate the transfer of technology, information on technology developments must be made available to the potential end-users seeking solutions to identified customer problems/needs. Conversely, information on end-user needs must be made available to the technology developer.

Three specific barriers impeding access to information are failure to write about new technology developments, failure to make writeups accessible and understandable, and chaotic storage of materials describing technology development (Olken 1985). In addition, a significant delay may occur between the time when research is completed and the time when individuals can access results through one of the federal technical information resource centers. A DOE study (1984) indicated that the published literature may lag the research by as much as 1-1/2 to 2 years. Some industries have expressed concern about sharing data with the government, because it may be accessible to competitors through the Freedom of Information Act.

Literature reviews are one of the main avenues available to technology seekers to identify potential technologies that may solve their particular problems. Reports, articles in professional journals or trade publications, and conference proceedings in the literature are typically written to communicate within the technical community. Other information dissemination techniques such as brochures, videotapes, and news releases can provide information to technology seekers on more fully developed ideas.

Cultural/Perceptual Differences

Even if information is made available in a timely manner and in a potentially useful form, it still requires the technology seeker to obtain, interpret, and use the information. From the perspective of the federal laboratories, the private sector is not making a concerted effort to seek technologies from the laboratories (ERAB 1988).

Several cultural or perceptual differences between the laboratories and the end-user could be creating the private sector's inaction. One of these is a "not invented here" attitude held by the private sector. Business seems reluctant to seek, adapt, and use knowledge that it did not develop (Greenberg 1988). Many private sector firms do not monitor the research conducted at the federal laboratories because they perceive the research, the bulk of which is conducted primarily to support federal government missions such as defense, to have little commercial application (Congressional Budget Office 1988).

The inherent risk (both technological and financial) associated with new technologies poses a significant barrier to technology transfer. Some end-users, such as industry, expect technologies to be "market ready," requiring little further development and testing expense. However, much of DOE's role during the past decade has been essentially limited to basic and applied research and has not included the production engineering and application demonstration stages required for a technology to be considered marketable. The near-term, bottom-line focus of the business community makes the financial risk involved in experimenting with new technologies and developing new products a significant barrier to technology transfer.

Changing Market Conditions

For various reasons, the technologies developed may not match the timing of the marketplace. Timing differences may arise because the nature of the market has changed between the time the research program was initiated and completed or because the research is directed to a long-term national need, typically not addressed through private sector research. For example, research was initiated on several alternative energy and conservation technologies during the 1980s when energy costs were relatively high. However, many of these technologies have not realized significant adoption rates because of the current relatively low price of oil.

INCENTIVES FOR TECHNOLOGY USE

The federal government through assistant programs, tax laws, and Office of Research Technology Applications have fostered technology use. Assistance programs such as the Small Business Innovation Research (SBIR) Program, the Energy-Related Inventions Program, and State and Local Assistant Program (SLAP) are all examples of governmental programs that either assist the small business, the individual inventor or the non-federal governmental bodies to benefit from federally-sponsored research or assist such entities to share ideas, information and technology with the federal government.

Tax Incentives

Federal tax incentives related to energy conservation and use of renewable energy sources can be divided into four categories: 1) various tax benefits not specifically related to conservation or renewables; 2) business tax incentives added to the Internal Revenue Code by the Energy Tax Act of 1978, as amended by the Crude Oil Windfall Profit Tax Act of 1980, (hereafter the "Energy Tax Act"); 3) tax incentives added by the Energy Tax Act to stimulate more efficient use of energy in transportation; and 4) individual tax incentives included in the Energy Tax Act to encourage residential conservation.

Examples of the first category include depreciation and the investment tax credit that was available through 1985. Depreciation is a deduction from gross income to provide a reasonable allowance for the exhaustion and wear and tear of business property. Energy and investment tax credits reduce a taxpayer's tax liability dollar-for-dollar because a credit is subtracted from tax otherwise due.

The Energy Tax Act provided for a tax credit for qualified investments in agricultural/commercial/industrial assets used to conserve energy. The credit ranged from 10 to 15% and was in addition to the investment tax credit. Eligible property was required to be new with a useful life of three years or more. The credit lasted through 1988 for solar, geothermal, ocean thermal, and biomass property. It lasted through 1985 for qualified hydroelectric property, wind property and intercity buses. The credit lasted through 1982 for other qualifying property including equipment fueled by alternative fuels and such equipment as heat exchangers, waste heat boilers, and recuperators.

The Energy Tax Act also contains several provisions applicable to transportation. One provision is the "gas-guzzler" tax for passenger vehicles that do not meet a specified level of fuel economy as measured by the Environmental Protection Agency. A second provision provided for reduced federal excise taxes for producers and users of gasohol. A third provision reduced excise taxes for qualified buses, bus parts, and the fuel used for qualified buses. Finally, a provision enhanced the attractiveness of the investment tax credit for purchase of vehicles used for van pooling.

The Energy Tax Act also provided for two categories of residential energy tax credits for individuals. The energy conservation credit was 15% of the first $2000 of qualified expenditures for energy conserving equipment installed between April 20, 1977 and December 31, 1985. Qualifying equipment needed a useful life of at least three years and needed to be installed in the taxpayer's principal residence which was required to be in the U.S. Examples of such equipment included insulation, storm doors and windows, caulking and weatherstripping, and automatic setback thermostats. The Act also provided for a tax credit of 40% of the first $10,000 of qualified expenditures for equipment using solar, wind, or geothermal energy for residential use.

Section 29 of the Internal Revenue Code also provides for a tax credit for the production of energy from alternative sources. The credit is generally $3 per million Btus (the energy equivalent of one barrel of oil) produced and sold. Energy eligible for the credit includes oil produced from shale and tar sands, gas produced from geopressured brine and biomass, synthetic fuels derived from coal, qualifying processed wood fuels, and steam produced from solid agricultural byproducts. Various time restrictions apply. In general, the credit is available through the year 2000 for facilities placed in service during the 1980s.

The federal government is naturally interested in the effectiveness of energy tax credits. The credits result in a loss of revenue to the government. The benefits of conservation investment must be sufficient to overcome the lost revenue. Moreover, the credits are only effective if they stimulate investment in energy conservation that would otherwise not occur. Estimation of the amount of conservation investment attributable to credits is made difficult because market forces also contribute to investments. If tax credits are made available for investments that would otherwise occur anyway, the taxpayer realizes a windfall at the expense of the government. A measure of effectiveness suggested by the General Accounting Office (GAO) is to compare the market value of energy savings attributable to the tax credit to the revenue foregone by the government.

Office of Research and Technology Applications

Most mature industrial and government laboratories will have an organization responsible for licensing technologies developed as part of their research and development (R&D) activities. Each DOE laboratory having a professional staff in excess of 200 must establish an Office of Research and Technology Applications (ORTA). The purpose of the ORTA is to support their R&D staff and evaluate the technical and economic feasibility of each invention, determine how the technology should be protected including foreign and domestic patents or copyrights, and promote those with the greatest potential. and begin to search for potential licensees. A license can be an effective method for transferring intellectual property (IP). The property is usually in the form of a patent, copyright, know how, or trademark. Through this process, the licensee gains legal access to a protected technology. Simultaneously, the licensor gains access to the resources of the licensee, and his access to markets. This combination of resources usually reduces risks and greatly enhances opportunities for a successful venture.

MANAGING TECHNOLOGY TRANSFER

Technology transfer programs are usually successful when they have well defined objectives, strategies, and mechanisms. The effectiveness of these programs will logically depend on several factors:

- objective of the technology transfer effort: Not all technology transfer efforts are aimed at introducing the technology into the marketplace. Some have the goal of transferring scientific knowledge, of moving the technology one more step, or of encouraging private sector investment.

Consequently, the goal of technology transfer programs must be considered when evaluating the effectiveness of a technology transfer effort.

- strategy of the technology transfer effort: Each technology transfer strategy will use different mechanisms and sequences of mechanisms to assist it in its technology transfer efforts. Mechanisms that seem effective in one program may be totally ineffective in others. Not only are the right mechanisms important, but also the execution of these mechanisms plays a role in program success.

- mechanisms of the technology transfer effort: The selection of mechanisms is a function of the stage of technology development, end users and other factors. For example, when the private sector is represented by a small number of firms, contracting R&D directly with such firms can achieve near instantaneous technology transfer and feedback. Technical journal articles may be more effective for providing technical information on a new idea early in the development process, while a workshop would be less effective at that stage of development.

- external factors: Other factors out of the control of the technology developer can influence a technology's adoption. For example, market conditions, such as decreases in the relative price of oil, have delayed the adoption of many alternative energy sources; or regulations such as increased environmental concerns could accelerate the adoption of a filtration technology.

At the outset, it must be recognized that not all of the federally-funded technologies have commercialization potential in the private sector. Some technologies typically are not developed for commercial production but to satisfy a specific mission of the federal government that may not have a private sector analogue. Therefore, statistics such as "only 5% of the 30,000 patents owned by the federal government are licensed for commercial use in the private sector" should be avoided in to evaluating the effectiveness of federal technology transfer programs (Soderstrom and Winchell 1986).

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The next section of this paper defines the broad categories of transfer mechanisms that researchers can use to help move a technology to the marketplace. The specific mechanisms within each category are defined with the advantages and disadvantages of each listed. The third section describes several technology transfer activities which illustrate strategies used to reach technology transfer objectives. The last section then summarizes some general findings from the cases studied and the method of documentation developed.

2.0 TECHNOLOGY TRANSFER MECHANISMS

The mechanisms used to transfer technology are grouped into eight categories:

- advisory groups
- research collaboration
- exchanges of personnel
- technical assistance
- licensing
- spinoff companies
- dissemination of information
- education.

Some of these categories use similar methods that have different audiences or situations in which they are most successful. For example, the categories most appropriate for basic research are different from those for exploratory, applied, development, or product improvement research. The categories also have certain optimal points at which they should be initiated in the technology development cycle.

Targeting the audience for any technology transfer effort increases the effectiveness of the effort. User facilities are an example of one-on-one transfer of technical information to the technical person(s) working at a different development stage or in a related field. Technical reports and new releases when disseminated to a targeted group--industrial decision makers, engineers or trade association representatives--can also be a desirable means of technology transfer.

Timing is also critical to the success of a technology transfer mechanism. For example, advisory groups are most appropriate for applied, development, or product improvement research and should be used before any research effort is initiated. On the other hand, workshops/seminars/conferences are most advantageous when research results are available.

Each mechanism has its own advantages and disadvantages. For example, contracting directly with industry can be time consuming, expensive, and inequitable, but it does reduce risk to both industry and the DOE by effectively passing on new technology information to an end-user. Likewise, dissemination of information reaches wide audiences but does not facilitate feedback, a primary ingredient of successful technology transfer.

The eight broad groups of mechanisms are listed in Table 1. In the remainder of the section, specific mechanisms within each category are defined, their advantages and disadvantages listed, appropriate situations for using it given, and examples of their use shown.

Some activities that deal with technology issues may seem to meet the definition are not actually technology transfer. Workshops designed to inform the public about a technology to be engaged near where they live, but implanted by others is not a transfer to the public because they do not use the technology. Another example is reports prepared for regulatory or litigation use. Such reports usually only repackage already available information and do not inform the potential technology user. Reports which have restricted distribution for national security reasons and also restricts the information receiver in the use of the technology does not fall with the definition of technology transfer mechanism used in this paper.

Table 1. Groups of Transfer Mechanisms

Advisory Groups

Research Collaboration

- Contracting R&D to Industry
- Working with Industrial Consortia
- Conducting Cooperative Research Projects with Industry
- Demonstration
- Sharing User Facilities
- Conducting Work for Others
- Private Consulting by Staff
- Working with Broker Organizations

Exchanges of Personnel

- Guest Researchers

Technical Assistance

- Staff Transfers to Industry

Licensing

Spinoff Companies

Dissemination of Information

- Workshops/Seminars/Conferences
- Information Dissemination Centers
- Mailings
- Technical Reports
- News Releases
- Articles in Trade Journals and Magazines
- Fact Sheets
- Videotapes
- Decision Tools
- Electronic Bulletin Boards

Education

ADVISORY GROUPS

DEFINITION: Industry and technical experts to help define and direct research and technology programs

ADVANTAGES:

- provides expert technical focus and industry "calibration" of research direction
- integrates research efforts and technology development with market realities
- provides regular on-going assessment
- allows groups to restructure to assure fresh perspective

DISADVANTAGES:

- provides limited points-of-view
- allows a "club" of like-minded experts
- can be conducive to conflict of interest
- requires thorough understanding of federal role by group members

APPROPRIATE SITUATIONS:

- when conducting all stages of R&D process, but particularly in applied, development and product improvement stages

EXAMPLES:

- Energy Research Advisory Board
- most technical advisory committees

RESEARCH COLLABORATION

Contracting R&D

DEFINITION: Industry, universities, or others as the research contractor with no cost sharing

ADVANTAGES:

- carries technically feasible ideas into commercial applications
- allows protection of existing proprietary information
- potentially reduces technology transfer costs
- enhances resources through cost sharing
- overcomes the "not invented here" syndrome

DISADVANTAGES:

- may be difficult to equitably select R&D partner
- creates lengthy contract paperwork cycle

APPROPRIATE SITUATIONS:

- when conducting product-oriented R&D
- when conducting all stages of R&D
- when appropriate R&D performer has the necessary resources and goals

EXAMPLES:

- Heat Exchanger Program
- Electric Vehicle Program
- Clean Coal Technology Demonstration Program
- Textile innovations through subcontracts with the Georgia Institute of Technology
- Low E windows
- Solid state ballast

RESEARCH COLLABORATION

Working with Consortia

DEFINITION: Government cooperation with groups of firms, trade associations, universities, or others to perform a research project or develop a new technology (may or may not include cost sharing)

ADVANTAGES:

- reduces private-sector risk
- focuses on market needs resulting in more transferable R&D products
- gains access to enhanced resources through sharing of equipment, funds, and experience
- overcomes the "not invented here" syndrome
- disseminates information quickly to industry
- confers legitimacy to research endeavor

DISADVANTAGES:

- may conflict with federal anti-trust laws
- may discourage sharing of private information due to proprietary interests
- discourages product development due to nonproprietary dissemination of information
- is difficult to assess interest of potential consortium members

APPROPRIATE SITUATIONS:

- when a group of firms faces a generic R&D problem
- when the risks and capital requirements are too great for a single firm to "go it alone"

EXAMPLES:

- Limited partnership involving Los Alamos National Laboratory
- Ceramics Advanced Manufacturing Development and Engineering Center (CAMDEC)
- Designs concepts for solar thermal buildings

RESEARCH COLLABORATION

Cooperative Research Projects

DEFINITION: Government, in conjunction with industry or a university contributes staff, equipment, and/or other resources to a common research project (cost sharing)

ADVANTAGES:

- reduces private sector risk
- accelerates technology transfer by working closely with a firm that has the ability and resources to develop and market derivative commercial products
- gains access to enhanced resources
- overcomes the "not invented here" syndrome
- promotes investment in an area of research and accelerates the technology development time line

DISADVANTAGES:

- may give one firm a market advantage
- depends on selecting an effective contractor
- may cause conflicts in ownership of intellectual property

APPROPRIATE SITUATIONS:

- when industry needs government support to maintain research
- when industry possesses unique expertise or technology position

EXAMPLES:

- Foam Dyeing Process
- Gel/Cell battery
- Superconductivity Research Center projects

RESEARCH COLLABORATION

Demonstration

DEFINITION: Government contributes equipment, technical expertise, installation expenses and/or other resources to accelerate the market penetration of a technology

ADVANTAGES:

- reduces private sector risk
- accelerates technology transfer by working closely with firms that are providers or end-users of the technology
- gains access to comparative in situ data on technology's performance
- overcomes the reliability issue of new technologies

DISADVANTAGES:

- may create a competitive advantage for a certain manufacturer
- depends on selecting a cooperative installation site
- requires follow on monitoring by DOE, developer or a National Laboratory
- may cause conflicts in cases of failures

APPROPRIATE SITUATIONS:

- when project costs are large
- when technology field is rapidly changing
- when marketplace requires access to industrial performance data

EXAMPLES:

- Clean Coal Technology Demonstration Program
- GTE Sylvania High-temperature Recuperator Demonstration Project

RESEARCH COLLABORATION

Sharing User Facilities

DEFINITION: Sharing the use of government-owned facilities with industry, universities, and others

ADVANTAGES:

- reduces private-sector capital requirements for conducting research
- gives industry and others access to sophisticated instrumentation and complex testing facilities
- promotes investment in an area of research and accelerates the technology development time line

DISADVANTAGES:

- engenders issues of proprietary rights and access to facilities

APPROPRIATE SITUATIONS:

- when industry is fragmented or too small to afford adequate research facilities
- whenever collaboration with industry the quality and timeliness of results

EXAMPLES:

- High Temperature Materials Laboratory at ORNL
- Analysis and Diagnostics Laboratory at ANL
- Window Thermal Test Unit (MoWitt) at LBL
- Roof Research Center at ORNL
- Fuels Evaluation Facility at PETC

RESEARCH COLLABORATION

Conducting Work for Others

DEFINITION: Conducting research for sponsors other than DOE

ADVANTAGES:

- gains access to enhanced resources
- provides incentive for broader participation
- may lead to broader knowledge transfer
- may lead to alternative applications of existing technologies

DISADVANTAGES:

- potentially allows conflicts of interest
- potentially increases contractual paperwork

APPROPRIATE SITUATIONS:

- when government and industry goals and needs match

EXAMPLES:

- risk assessment and hazards research for FEMA, EPA, and NRC
- parallel processing, decision support systems, geographic information systems, and other computer applications for DOD
- research for utility companies
- Desalinization program for the Department of the Interior

RESEARCH COLLABORATION

Private Consulting by Staff

DEFINITION: DOE or DOE laboratory staff consulting with industry, universities, or others

ADVANTAGES:

- retains research staff
- may create the small business infrastructure necessary to produce and market new technologies
- enhances the entrepreneurial resources of a community and region
- exposes research staff to market conditions
- accelerates transfer of research results from DOE research projects to other potential users

DISADVANTAGES:

- potentially allows conflict of interest
- may distract from research

APPROPRIATE SITUATIONS:

- when clear rules and procedures exist to protect and manage intellectual property

EXAMPLES:

- Air Infiltration Measurement System developed by BNL employees through their own company (AIMS, Inc.)

RESEARCH COLLABORATION

Working with Broker Organizations

DEFINITION: Trade, professional, special governmental, and regulatory organizations as "brokers" to carry out the technology transfer process

ADVANTAGES:

- often provides an effective channel for assessing industry needs and sharing research results
- focuses on market needs resulting in more transferable R&D products
- can be inexpensive
- enhances resources through cost sharing
- disseminates information quickly to industry
- confers legitimacy to research endeavor

DISADVANTAGES:

- may distort or limit information transfer
- potentially inadequate feedback

APPROPRIATE SITUATIONS:

- when an effective communication network already exists within an industry's associations and organizations
- when limited resources are available for technology transfer
- at all stages of the R&D process, but less appropriate for the development of new commercial products

EXAMPLES:

- State and Local Assistance Program (SLAP)
- Federal Energy Management Program (FEMP)
- Unequal parallel compressor systems for supermarket refrigeration
- Cement-grinding technology

EXCHANGES OF PERSONNEL

DEFINITION: The temporary assignments of personnel from one organization to another

ADVANTAGES:

- allows one-on-one exchange
- protects proprietary information
- provides industrial feedback on technology development
- overcomes "not invented here" syndrome

DISADVANTAGES:

- requires selection and relocation of technical personnel
- may lead to conflict of interest

APPROPRIATE SITUATIONS:

- when conducting all stages of R&D process but particularly during development of basic technology for products and product development

EXAMPLES:

- Northwest College and University Association for Science (NORCUS)
- exchanges with Electric Power Research Institute (EPRI)
- assignment of field personnel to Headquarters
- teaching assignments with universities

TECHNICAL ASSISTANCE

DEFINITION: Disseminating information by personal visit, letter or telephone call to clarify a previously published result or to amplify such data

ADVANTAGES:

- provides specific information exchange
- allows one-on-one interchange
- generally, accelerates technology transfer

DISADVANTAGES:

- encourages off-the-cuff answers to questions
- exposes information to limited audience
- creates additional expenses with assistance

APPROPRIATE SITUATIONS:

- during product development, demonstration and deployment
- when R&D is at all stages

EXAMPLES:

- Center for Metals Fabrication
- National Institute for Standards and Technology
- NASA Industrial Applications Centers
- Fossil Energy Technology Centers

LICENSING

DEFINITION: The issuance of either an exclusive or non-exclusive permit to manufacture a product

ADVANTAGES:

- carries technically feasible inventions into commercial production
- allows protection of proprietary information
- potentially accelerates technology transfer
- allows many firms to benefit when the market is large

DISADVANTAGES:

- requires thorough industry knowledge to select licensees
- may create liability problems
- consumes time and can be expensive to implement

APPROPRIATE SITUATIONS:

- when conducting product-oriented R&D

EXAMPLES:

- Biobarrier
- Chemchek Instruments, Inc.
- Hydrostar
- Whisker-toughened ceramics

SPINOFF COMPANIES

DEFINITION: The creation of a new company with personnel involved in the technology development

ADVANTAGES:

- carries technically feasible inventions into commercial production
- enhances company's technical position
- potentially reduces technology transfer costs
- enhances resources through cost sharing

DISADVANTAGES:

- potential incorporation difficulties
- loss of valuable employees
- may be perceived as unfair by other potential recipients

APPROPRIATE SITUATIONS:

- when R&D is product oriented
- when R&D is service oriented

EXAMPLES:

- Ion Guard (PNL)
- Vernix Research Corporation (BNL)
- Glasstech Solar, Inc. (SERI)
- M. D. Spenser (Argonne)
- Anaerobic municipal waste processing system (ANFLOW, Inc.)

DISSEMINATION OF INFORMATION

Workshops/Seminars/Conferences

DEFINITION: Meetings of varying degrees of formality and format to convey technical information

ADVANTAGES:

- encompasses presentation to audience of several or many; saves time, travel, duplication
- offers personal contact with prospective user
  - provides opportunity for dialogue and networking
  - may enhance credibility with face-to-face contact
  - offers familiar environment for most researchers
  - includes select audience (would not attend unless interested)
  - may result in synergy from variety of viewpoints and experience

DISADVANTAGES:

- requires travel to bring audience and presenters together (except for teleconferences)
- may inhibit sharing of proprietary or sensitive information
- creates additional costs in organization and arrangements

APPROPRIATE SITUATIONS:

- when disseminating nonproprietary information
- when feedback from peers is sought
- when presenting materials for widespread use, e.g., technical guidebooks
- when intent is to maximize dissemination
- when material is not easily understood (from printed text, video, etc.)

EXAMPLES:

- technology transfer workshops and similar meetings in which audience is composed of prospective users with incentive to acquire new technologies
- conferences in which audience is composed of peers and "interested bystanders"

DISSEMINATION OF INFORMATION

Information Dissemination Centers

DEFINITION: Centralized resource for authoritative information and data in particular a field of technology; often includes the ability to provide definitive responses to technical inquiries, copies of technical reports, technology summaries, etc. (called Information Analysis Centers in DOD network)

ADVANTAGES:

- offers single point of contact for wide variety of users
  - generally located in organization with authority and credibility in subject field
  - reduce searching many sources
  - typically provide qualified information and data, i.e., reviewed by experts before release
  - frequently channel requests to researchers or engineers with expertise in field
  - serve as centers of networks encompassing both suppliers and users of technology
  - function as effective referral centers
    * often have associated computer databases available online
    * provide access to numerous outside computerized databases

DISADVANTAGES:

- limits amount of resources (usually not given high priority in budget processes)
- often requires (by sponsor or by limited resources) a charge for services, reducing accessibility and utilization.
- unable to handle/disseminate proprietary information

APPROPRIATE SITUATIONS:

- when responding to searches for technical data, research-in-progress, references (people and publications)
- when disseminating nonproprietary data
- when building of networks of experts and authoritative sources

- when responding to specific inquiries asking for assistance on technical applications

- when providing bibliographic searches from computerized databases

EXAMPLES:

- DOD Metals and Ceramics Information Center, Machinability Data Center, Reliability Information and Data Center, Composites Information Analysis Center, etc.

- DOE National Energy Information Center, Office of Scientific and Technical Information, National Appropriate Technology Assistance Center, Solar Technical Inquiry Service, Conservation and Renewable Energy Inquiry and Referral Service, etc.

- classified information centers, e.g., DOD centers dealing with SDI technologies, nuclear weapons, etc.

DISSEMINATION OF INFORMATION

Mailings

DEFINITION: Dissemination of information, research results, technology opportunities by mail to selected or wide audiences

ADVANTAGES:

- are relatively inexpensive
- can reach a large number of people
- bring information to desk of prospective user, rather than user action to secure information

DISADVANTAGES:

- lacks one-on-one contact, dialogue, response to questions, etc.
- suited only to nonproprietary information
- usually reaches only a few actual users
- lacks priority for attention
- requires recipient to take initiative to read, understand and use
- subjected to wastebasket syndrome.

APPROPRIATE SITUATIONS:

- when widespread dissemination of nonproprietary information is needed
- when needing offerings or solicitations to which unrestricted access is required by law or policy
- when publicizing developments that have extensive applications
- when targeting selected audience known to have specific interest

EXAMPLES:

- mailings to established networks, e.g., researchers in given field, new technology managers
- mailings to selected audiences, e.g., announcement of availability of license

- broadcast or random mailings to unspecified and unqualified audiences (e.g., "Occupant")

- mailings describing capabilities or interests but not available results (e.g., "we do good stuff and can solve any problem")

DISSEMINATION OF INFORMATION

Technical Reports

DEFINITION: Formal reports documenting progress or results of R&D projects

ADVANTAGES:

- provide established, familiar formats
- can (should) provide comprehensive technical and scientific information
- usually include good source of references
- document results in permanent, accessible manner
- usually have been peer and/or management reviewed
- provide continuing archive of R&D on specific subject

DISADVANTAGES:

- lacks breadth of scope
- subject to dissemination policy and quality limitations
- may be too technical to interest prospective commercial users

APPROPRIATE SITUATIONS:

- when disseminating to peers and to scientific/technical audiences
- when in second stage of technology transfer, i.e., to provide technical details, data, information for duplicating development
- when sharing progress in collaborations
- when documenting progress and results for reference and archiving purposes

EXAMPLES:

- dissemination of technical reports to scientific and technical audiences in industry, academia, and laboratories
- supporting documentation for licenses

DISSEMINATION OF INFORMATION

News Releases

DEFINITION: Nontechnical summaries of research developments disseminated to public media

ADVANTAGES:

- can reach wide audiences through print and electronic media
- can be placed in publications known to be read by decision makers (e.g., Wall Street Journal)
- publicize DOE R&D program benefits
- are easily and quickly prepared
- attract interest of many publications
- offer opportunity to gain public recognition for researchers and inventors

DISADVANTAGES:

- subject to DOE policy approval, which can create lengthy delays
- cannot communicate proprietary or complicated technical information
- subject to timing constraints and individual editors's style

APPROPRIATE SITUATIONS:

- when seeking to create public awareness of significant developments
- when endeavoring to reach policy and management audiences not generally accessible through more direct route
- when seeking to publicize benefits of DOE R&D and of individual labs

EXAMPLES:

- news releases directed to specific editors of publications (or other media) known to have interest in R&D news items
- saturation mailing of news releases of limited interest to media, limited news content, or of highly technical nature

DISSEMINATION OF INFORMATION

Articles in Trade Journals and Magazines

DEFINITION: Articles and reports prepared by DOE laboratory (or contractor) for specific business publication

ADVANTAGES:

- reach audience that is known in advance
- target audience presumed to have specific interest in the field of technology
- provide a relatively low cost for dissemination to large but selective audience
- build credentials of the developer as a producer of useful technology
- establish the developer as a member of, or active in support of, a particular business/trade community
- offer useful publicity for individual researchers or engineers
- may generate requests for further information from trade publications that have reply cards

DISADVANTAGES:

- lacks suitability for proprietary information
- does not allow for one-on-one contact or dialogue
- fails to target proper individuals to read articles

APPROPRIATE SITUATIONS:

- when widespread announcement of new development is needed
- when part of purpose is to provide visibility

EXAMPLES:

- articles in carefully selected journals serving target sectors for application of new technology

DISSEMINATION OF INFORMATION

Fact Sheets

DEFINITION: Brief summaries of a research development, accomplishment, or product, including information on applications, relevant data, etc.

ADVANTAGES:

- are inexpensive and quickly prepared
- offer variety of uses, such as handouts, mailing pieces, background for news releases, response to inquiries, etc.
- can capsulize relevant information for quick and easy understanding (usually written for less technical reader)
- may be assembled in a set to cover a scope of technologies or applications
- are easily updated

DISADVANTAGES:

- lacks length to include all relevant information
- lacks applicability for both technical and less technical audiences

APPROPRIATE SITUATIONS:

- when first determining interest in a new technology
- when mailing piece to selected prospective users (who are encouraged to request more information)
- when needing handouts at exhibits, technical and professional conferences, and for visitors
- when providing additional background information with news release (if editor wants to expand on release content)

EXAMPLES:

- National Aerobatics and Space Administration Tech Briefs
- Office of Science and Technical Information Energy Grams
- Pittsburgh Energy Technology Center techlines

DISSEMINATION OF INFORMATION

Videotapes

DEFINITION: Formal, scripted video programs or informal videos of experiments, tests, etc.

ADVANTAGES:

- can show action, color, sound, etc.
- are fairly inexpensive to prepare
- allows considerable mobility (equipment), does not require high degree of training
- are easily edited
- compress information (large volume in short time)
- are easy to duplicate and distribute
- can be shown to large or small audiences
- can be transmitted via electronic media

DISADVANTAGES:

- are inappropriate for large audiences
- are time-consuming
- are difficult to update
- lack standardization in tape sizes and formats

APPROPRIATE SITUATIONS:

- when preparation time is limited
- when presentation time is limited
- when quick (e.g., overnight) exchange of raw information, such as experiments or tests, is needed
- when material is need for exhibits and trade shows

- when giving management or policy-level briefings
- when disseminating to electronic media

EXAMPLES:

- Argonne Technology Transfer Review
- SERI Shop Doctor Video

DISSEMINATION OF INFORMATION

Electronic Bulletin Boards

DEFINITION: Visual presentation of information on computer screen via interactive online electronic network

ADVANTAGES:

- offer timely information instantly, on screen or in printed form
- allow user to interact with originator of information
- allow originator to transmit directly without intermediaries
- offer low-cost communication directly with user
- provide information to many users concurrently
- offers selective transmissions; i.e., different audience can be chosen for each message

DISADVANTAGES:

- needs necessary equipment (PC, modem, etc.)
- potentially lacks real-time interaction
- lacks confidentiality of communication
- lacks management review before transmission
- needs network, i.e., users must be identified, trained, interested in participating

APPROPRIATE SITUATIONS:

- when presenting informal notices, progress reports, development summaries, etc., to selected audiences
- when providing calendars of events to large numbers of people
- when time is critical and time zone differences prevent direct communication
- when keeping large number of participants current on rapidly changing developments
- when disseminating inquiries to large number of potential respondents

EXAMPLES:

- Federal Laboratory Consortium Electronic Mail Network
- Federal Laboratory Consortium Clearinghouse
- Fossil Energy Telenews

DISSEMINATION OF INFORMATION

Decision Tools

DEFINITION: Computer programs employing logical reasoning to make choices between options; used for training, for design studies, for diagnostic routines--potentially useful for transferring new concepts from origin (e.g., DOE lab) to user organization

ADVANTAGES:

- condense complex concepts to computer codes that may need relatively little training to use
- convey easily from origin to user (via software or electronic communications)
- may be copyrighted
- reduce potential for error or misunderstanding in transferring complex concepts
- adapt to most PCs and computer formats

DISADVANTAGES:

- has high cost in preparation and debugging
- requires access to computer capabilities and some training required
- requires user willingness to use such tools
- lacks widespread application (e.g., to decision tree processes_

APPROPRIATE SITUATIONS:

- when transferring decision process tools and techniques
- when disseminating decision tools to broad professional audience (see below)
- when expert who originated concept will no longer be available (e.g., retired) or cannot provide personal training

EXAMPLES:

- LANL/SERI Residential Builders' Guidelines (simple decision tree system for selecting energy efficient options to optimize design; disseminated to homebuilders' organizations in many cities)

EDUCATION

DEFINITION: Promote improved public knowledge of energy issues and technologies

ADVANTAGES:

- offers long-term benefits of reducing resistance to new technologies
- can promote technology transfer through market pull
- creates better educated next generation of practitioners

DISADVANTAGES:

- can be expensive
- limits access

APPROPRIATE SITUATIONS:

- when there is a nationally recognized need
- when complex information needs to be conveyed, and lack of knowledge and understanding is a major barrier

EXAMPLES:

- Energy Institutes for Engineering and Architectural Faculty
- Methanol Marathon
- Commercialization Planning Workshops

3.0 STRATEGIES AND OBJECTIVES

To demonstrate how technology transfer programs' objectives have been met through the strategic use of mechanisms, a brief synopsis of a number of technology transfer programs are presented in this section. Their objectives, strategies, and representative results are summarized. In addition, the unique combination of mechanisms used in achieving their objectives are discussed.

OBJECTIVES

Successful technology transfer programs have one or more definite objectives. The following explicit/implicit objectives were found to be used by most technology transfer programs:

- to transfer scientific knowledge
- to move a technology into the next step/stage
- to encourage private sector investment or redirection of private sector research programs
- to obtain feedback from users (demonstration projects, advisory panels, user facilities)
- to improve the nation's technology base
- to introduce a new technology into the market
- to enhance/accelerate user acceptance and use
- to expand alternative technology applications (spinoffs).

The first objectives in this list are more appropriate to linking the early stages in technology and business development. Objectives lower in the list are usually linked to the later stages of technology development.

DEFINITION OF TECHNOLOGY TRANSFER STRATEGY

While a carefully planned strategy for using the many mechanisms available to the technology-developing organization is crucial to successful technology transfer, the transfer of technical information does not ensure a technology's application. Strategies which use mechanisms that encourage feedback are the most successful. Combinations of mechanisms applied in a systematic manner and at the opportune time constitute a technology transfer strategy.

Targeting the audience for any technology transfer effort increases the efficiency of the effort. User facilities are an example of one-on-one transfer of technical information to a targeted group of technical people working in a related field. Technical reports and news releases when disseminated to a targeted group--industrial decision makers, engineers or trade association representatives--can also be a desirable means of technology transfer, although they lack feedback.

Timing, how quickly an application can occur, is critical to the success of a technology transfer mechanism. Energy prices can change and competing technologies can be introduced into the market during the typically long period between concept development and a market-ready product. Therefore, expedient completion of research, patenting, licensing, etc., is vital to the overall success.

GRAPHICAL ILLUSTRATION OF A TECHNOLOGY TRANSFER PROGRAM

The example shown in Figure 2, illustrates graphically the transfer of a new weld vision system technology to the private sector. The technology was developed at the Idaho National Engineering Laboratory (INEL) in a program sponsored by Basic Energy Sciences of DOE.

The timing (in terms of stage of development) and level of effort invested in specific mechanisms are indicated by the location and width of the bars, respectively. Bar shading indicates the effectiveness of the particular mechanism in meeting the mechanism objective. Bar width indicates the relative level of effort invested in a particular mechanism. It is entirely possible for the mechanism objective to be met, yet the overall strategic objective may never be achieved.

In this example, feedback from industry was effectively used during the early stages of development. Industry made effective use of INEL's Welding Laboratory, and technical progress reports were issued through the National Technical Information Service (NTIS) system. A short video tape was made describing the new process and was effective in establishing a Work for Others contract. Licensing is shown in Figure 2 with light gray shading since it was not successful. Eventually a successful spinoff company was formed after the licensing process appeared to be going too slowly in spite of vigorous efforts by INEL personnel.

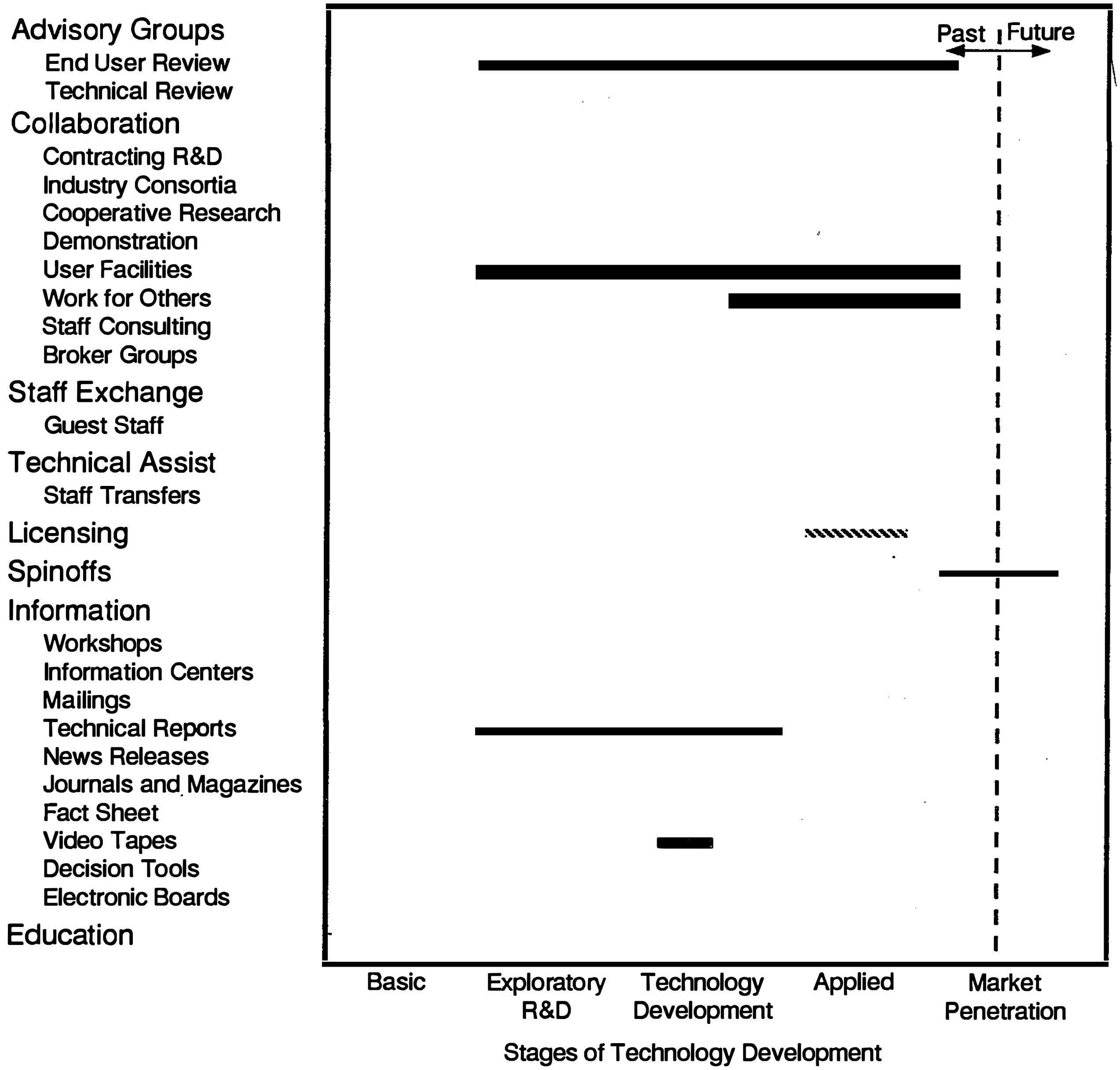
The strategy and choice of mechanisms were altered as the technology matured. It would be difficult to allocate technology transfer contributions to specific mechanisms. A product champion was crucial to progress from the exploratory R&D stage of technology development to market penetration.

EXAMPLES OF STRATEGIES FOR SELECTED OBJECTIVES

Case histories for a number of programs that use a combination of technology transfer mechanisms are presented on the following pages. These programs were selected because they illustrate the objectives listed above. These programs frequently have more than one technology transfer objective.

DOE Innovative Concepts Program

The DOE Innovative Concepts Program (ICP) is sponsored by the Inventions and Innovations Program in the Office of Energy Utilization Research. Since planning was initiated in 1981, the program has operated on an "invention laboratory" scale, completing three highly successful cycles.



Key:

- Area of bar is proportional to the amount spent for the technology transfer mechanism.
- Shading of bar is an estimate of the technology transfer mechanism's effectiveness.

Very successful

Somewhat successful

Not very successful

Figure 2. Technology Transfer Strategy Using New Weld Vision System as an Example

Objective

The ICP's objective is to move technology into the next step/stage. It matches new technologies with important market problems/opportunities and in so doing, increase the inventory of potential new programs available for government and industry funding. Thus, it encourages the formulation of fundamentally new approaches to saving energy and improving industrial efficiency and introduces the resulting concepts (intellectual capital) to potential sponsors.

Strategy

The ICP is differentiated from other DOE programs by its highly specific objective of **moving technology one more step** and by the very limited funding it provides to participating innovators. Although funding is limited, it is leveraged by substantial non-financial technology transfer assistance to participants. The ICP strategy blends several technology transfer mechanisms into the ICP process.

First, a needs assessment conducted by DOE focuses on users' needs to identify important problems on which innovators can focus. Mailings, news releases, and Commerce Business Daily (CBD) notices inform potential innovators of ICP's interest in concepts that fit the problem selected. Several hundred magazines are notified of the program interest, and, in addition to the obligatory CBD notice, advertisements soliciting innovators and their concepts are placed in key publications.

Serving as advisory groups, technical review committees screen the proposals submitted and select winning concepts. The ICP provides $15K to $20K contracts to selected innovators in industry/academia to conduct a preliminary assessment of the technical and economic feasibility of the innovator's concept, and provides direct technical assistance (guidance) in efficiently evaluating the concept's technical and economic potential. The ICP process identifies and nurtures technology champions.

Technical reports, mailings, news reports, workshops/seminars/conferences, articles in trade journals and magazines, and fact sheets are used to publicize the concepts. The ICP hosts a technology fair (conference) at which the chosen concepts are presented, and innovators meet potential sponsors face to face. Technical assistance is also provided in the form of a brief commercialization planning workshop. The program encourages the innovator to become a product champion.

Results

Before the program was initiated an objective was established: one concept out of ten had to receive follow-on funding before the program could be considered a success. Out of 32 concepts (from 3 program cycles) funded for approximately $15K each, 13 have received follow-on funding totaling $3 million. The program is regarded as highly successful. A major factor in the program's success is its encouragement of face-to-fact communication between innovators and industry/government program managers. This process facilitates feedback.

Comments

DOE management has recommended that the methods developed in this program be applied to national laboratories. Innovative concept solicitations are being used on a limited basis by DOE technology program managers. ICP technology fairs now showcase innovations from the Energy Related Inventions Program and the Small Business Innovation Research Program in addition to those funded by the ICP.

DOE's Combustion Research User Facility

The DOE's Combustion Research User Facility (CRF) is sponsored by the Office of Basic Energy Sciences (BES). The facility is operated by Sandia Corporation and is located at the Lawrence Livermore Laboratory, Livermore, California. The CRF has operated since 1980 and has a staff of 100.

Objective

The facility's objective is to enhance/accelerate user acceptance and use and to obtain feedback from users. It fosters the rapid development and application of combustion technology using advanced instrumentation, computational tools, and science developed in carrying out the DOE mission. The DOE mission had supported the development of extremely powerful equipment and methods for analyzing rapidly occurring nuclear events. These methods and tools could be applied to efforts to gain a better understanding of fossil fuel combustion. Better understanding of combustion processes leads to substantial energy savings, since approximately 90% of the energy used in the U.S. comes from the combustion of fossil fuels.

Strategy

The program seeks to catalyze technology development by bringing together scientists and engineers from various organizations to meet for short visits or to work together for extended periods in a well-equipped facility. Sandia scientists and engineers work on various combustion programs in the CRF, while visitors work on their programs in adjoining facilities.

Several technology transfer mechanisms operate in this environment. Exchanges of personnel are especially effective because they are supported by excellent user facilities. Cooperative research projects with industry are carried out in the CRF where industry and Sandia personnel work together on the same project. Joint technical reports are written by staff and industry personnel. One of the strengths of the CRF is that BES encourages cooperation with other programs both within DOE and industry. For example, DOE's Energy Conversion and Utilization Technologies (ECUT) program (carried out at the CRF) has supported research leading to new internal combustion engine (ICE) technology and to the development of computer tools to help industry design superior ICEs. The ECUT program made extensive use of industry advisory groups in planning its program and in transferring new methods back to industry.

Results

Several new technical developments now in the marketplace were developed in collaboration with CRF staff. Some of these include the Lennox Pulse Furnace, which is more than 90% efficient; and the improved combustion chamber and pulse preserving manifolds now in use in Cummins diesel truck engines. This Cummins engine technology is superior to that of the Japanese. Cummins holds 50% of the market for heavy diesel truck engines in the United States, even though it manufactures no trucks.

Comments

The Sandia CRF has been highly successful, and much of this success is due to its collaboration with industry. In the overall process, a number of transfer mechanisms encourage effective **two-way face to face communication between government-funded researchers and industry engineers over an extended period of time.**

Strategic Defense Initiative Organization

The Strategic Defense Initiative (SDI) is a research and technology program whose mission to develop a strategic defense system against intercontinental ballistic missiles, using the state-of-the-art technology.

Because the scope of this approach is broad, the products and processes generated from SDI research also serve as a source of technological innovations for other private and public sector R&D efforts.

Objective

SDI's objectives are to transfer scientific knowledge to industry and the public, and to expand alternative technology applications (spinoffs). SDI accomplishes this 1) by identifying emerging technologies that have potential applications for other public and private sector R&D efforts, and 2) by providing information about these technologies to interested parties from private and public sectors who can use the knowledge in other projects and ventures.

Strategy

SDI uses several technology transfer mechanisms: electronic bulletin boards, advisory groups, technical assistance, information dissemination centers, decision tools, and fact sheets. The SDI Technology Applications Program facilitates technology transfer by linking end users with the inventors and developers of the technology. The SDI Technology Applications Program does this by using

- "technology-push" mechanisms such as the Technology Applications Information System, a data base referral system that provides information on SDI-developed technologies to interested parties

- "requirements-pull" mechanisms such as technology applications advisory committees and panels to match public and private sector requirements with SDI technologies that can be integrated or customized for those needs.

- identifying emerging SDI technologies that have commercial applications or applicability to other U.S. public and private sector research and development (R&D) efforts

- providing information about these technologies to qualified U.S. corporations, small businesses, entrepreneurs, universities, and state and local governments who use the technologies for other commercial or R&D purposes.

- placing descriptions of technologies onto a free online data base service called the Technology Applications Information System (TAIS). TAIS contains more than 1,300 unclassified, nonproprietary abstracts identifying SDI technologies in such areas as superconductivity, sensors, lasers, supercomputers, electronics, materials, and industrial processes. Entrepreneurs and researchers can use the TAIS to identify potential investment opportunities, supplement R&D activities, or facilitate moving an emerging technology from the laboratory to the marketplace.

Results

SDI has had several successful technology transfer experiences through its Technology Applications Program:

SDI Materials Used in Automotive Engine and Space Structure Components

High-temperature carbon fiber ceramic materials, such as silicon nitride, were originally developed to extend material properties using a carbon matrix and/or carbon fiber coating technology. The developer, the Sullivan Mining Corporation, is a small business in San Diego, California. The materials are now being evaluated by Chrysler Corporation for use in automobile engine components and as a fluidic control device for the NASA space shuttle booster engines.

The Chrysler Corporation is presently testing a silicon nitride roller cam follower produced by Sullivan Mining. According to initial laboratory test results, it is more than five times durable than case-hardened steel rollers currently used in automobile engines and will be less expensive to manufacture.

Sullivan ceramic materials are also being used to develop a new fluidic control device for NASA space shuttle booster engines. A high-temperature probe made from the Sullivan-developed ceramic materials has been designed so that it can be inserted into the rocket nozzle exhaust, induce thrust vectoring, and shift the shuttle rockets' direction as necessary. This fluidic control device is now being tested as a replacement system for the heavier, more costly and complex gimbal systems currently used.

In addition, the SDI Technology Applications Program appears to have had a number of successes in its spinoff efforts. Nearly 30 such spinoffs in the areas of medicine, space technology, agriculture, and industrial materials and products have been identified. In the energy area alone, spinoff achievements include superconducting magnetic energy storage, oil well exploration, and applications of SDI pulse power transmission technology to oil well drilling.

National Institute of Standards and Technology

The National Institute of Standards and Technology (NIST) is the new name of the Commerce Department's National Bureau of Standards (NBS). The new name reflects the agency's broadened role and new responsibilities. NIST maintains traditional functions of NBS and continues to offer the full array of measurement and quality assurance services that were provided by NBS. In addition, NIST has been directed to develop four new major programs aimed at the rapid and effective transfer of technology to U.S. industry to enhance the country's technological competitiveness.

Objective

The objective of the new programs is to introduce new technologies into the market and to improve the nation's technology base. NIST aggressively encourages the use of new technologies in American industry.

Strategy

Regional centers for the transfer of manufacturing technology are intended to provide direct support to small- and medium-sized manufacturing firms in automating and modernizing their facilities. They will help businesses develop technically and financially sound plans for modernizing their production, particularly using modern manufacturing technology. The regional centers will draw on the scientific resources of NIST. NIST will create these centers in partnership with nonprofit organizations established by state and local governments, universities, or companies. NIST may provide up to 50% (limited to $3 million annually) of the operating (but not construction) funds for these centers for their first three years. NIST can provide decreasing amounts of operating funds for the next three years. After six years, the centers should be self-supporting.

NIST is to take an active role in promoting the transfer of federal technology by providing assistance to existing state and local technology extension services. Such state and local programs typically emphasize business advice rather than dealing with sophisticated technology. The NIST program will help to coordinate the state and local extension services with federal technology transfer programs. Through workshops, seminars, and other mechanisms, NIST will help technology extension agents make the best use of federal resources.

Through an advanced technology program NIST will work to speed the commercialization of new technology and the development of new, generic manufacturing techniques. The program will be aimed at small- to medium-sized, high-technology firms or consortia. NIST will provide relatively small amounts of funds to leverage private investment in specific projects to develop new products and processes. Candidate projects would include, for example, promising inventions evaluated under the program mentioned above.

NIST will establish a clearinghouse for state technology programs to gather and analyze information on the many state and local technology development programs across the nation. A central base of information will be developed on what programs are available, what has been tried, and what the results have been. The clearinghouse will be a resource for state and local governments as they decide on new technology policies. The information will be shared through workshops and other mechanisms.

Results

Microwave energy for sample digestion with mineral acid in closed Teflon® vessels affords a means of rapid heating to temperatures substantially above the normal boiling points. At these elevated temperatures many materials decompose rapidly. The NIST has played a leading role in placing this emerging technology on a scientific footing; and CEM Corporation, a maker of microwave equipment for laboratory and research purposes, worked with NIST in systematic studies of this new technology.

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A book on sample preparation using microwave techniques is being edited for the American Chemical Society. This compendium will allow industrial chemists to predict temperature and pressure conditions and use this new technology safely. Publications, special symposia, and meeting reports on the topic led to one-on-one consultations with hundreds of companies. In addition to the collaborating company, CEM, over 450 researchers from other companies, universities, and research laboratories have requested information or come to NBS to learn of this new technology.

The development of closed vessel microwave acid decomposition has increased the productivity of many industries doing elemental analysis. Depending on the sample type, preparation times have been cut from 8 hours to 20 minutes. As a result, many industries are using microwave assisted decompositions as the predominant method of sample preparation. Some of America's largest companies have applied this new technique to sample types such as oils, nuclear fuels, plastics, foods, medicines, ores, and environmental samples. Volatile elements such as selenium, phosphorus, tellurium, and vanadium can be quantitatively retained in these sealed vessels using microwave decomposition prior to instrumental analysis.

Because microwave digestion occur in a well-defined, precisely controlled system, they are suitable for integration into automated applications. Acid digestion conditions have previously been too arbitrary for automation.

Research has been conducted to identify fundamental relationships and to develop methods that allow the analyst to predict the conditions that will be generated during microwave digestion before programming and running the equipment. As a result, many new applications as well as historically difficult problems can be dealt with using this new technique. The technique has been tested on all the major sample types including biological, botanical, geological, alloy, and glassy samples and has demonstrated advantages for each of these sample groups.

These four major programs have only recently been established at NIST, so there is very little experience on which to assess the results. A limited effort was initiated in FY 1988 under the regional centers for the transfer of manufacturing technology, but it is too soon to assess whether that particular program has been successful.

Idaho National Engineering Laboratory's (INEL) Welding Laboratory

The Weld Vision System was developed in response to an actual problem at INEL's welding laboratory. High luminosity generated by the electric arc in welding makes it difficult to observe the actual weld site. As a result, precise weld sizing and detection of weld defects have been a problem. The fact that up to 30% of the costs for industrial welding can be attributed to quality control provided additional impetus for a solution.

By allowing the weld to be viewed in real time, the Weld Vision System provides researchers with a diagnostic and process control tool to deal with these problems. Initial research on the system was funded by internal laboratory funds. The project eventually became an integral part of a welding research program funded by the DOE's Office of Basic Energy Sciences.

Weld Vision uses a stroboscopic light, produced by a xenon flash lamp or a pulsed laser light source, to illuminate the welding site. Images of the welding site are then recorded with a small solid-state video camera, which is located behind an image intensifier tube. The tube is shuttered electronically and synchronized with the flash, which blinks once per video frame. This technique almost completely eliminates the light emitted by the welding arc and allows for high quality video pictures that can be easily interpreted by a welding operator or by electronic image processing equipment.

Objective

The objective of this example of technology transfer was to introduce a new technology into the market.

Strategy

After leading the research work, Mr. Jon Bolstad (an INEL employee) produced a video cassette featuring welding sequences for carbon steel, stainless steel, and aluminum, and provided it to companies with advance welding applications. Near the end of 1984, he contacted FMC. This contact eventually lead to a Work-for-Others contract with FMC which, in turn, led to enhancements that have brought the system to its present level of sophistication. As part of this contract, a prototype system was delivered to FMC.

Application for a patent was made. In 1986, the patent was issued, specifying Bolstad as the inventor of the technology, with all rights assigned to the DOE. DOE waived those rights to EG&G, Inc., with the understanding that EG&G would act to commercialize the technology, either by direct corporate new venture activity (i.e., spinoff company) or by licensing it to others.

Results

In October of 1986, Jon Bolstad, Michael Ward, and Craig Shull (other members of the research team) formed a spinoff company, Control Vision, Inc. Bolstad, the only fulltime employee of Control Vision, is President, and Ward and Shull support the company as part-time consultants. EG&G and Control Vision negotiated a license granting Control Vision exclusive rights to the weld vision technology. The license agreement was signed in August of 1988.

Control Vision has completed a R&D contract for a prototype system with Martin Marietta Corporation's, Manned Space Systems Division. Other customers in the aerospace and "high tech" industries have shown interest. While most potential customers are interested in custom systems for their own applications, a standard product that will have a lower price tag is being developed.

Comments

This example of technology transfer illustrates the important role that a "technology champion" can play in a successful transfer. Largely through the efforts of Jon Bolstad, this technology has been transferred to private industry. In response to a letter request from the ERAB Research and Technology Utilization Panel, FMC Corporation's Richard Kazares stated, "Looking back on this technology transfer activity, I could comment that the energy, persistence, and ability of the innovator (Mr. Bolstad) played the key role in the ability of FMC to team with the Government to transfer this important capability. It was his belief in the technology, and the ultimate success of the program that kept our interest and the system in sync."

National Aeronautics and Space Administration (NASA)

NASA's technology utilization program is the oldest and most sophisticated of the agency technology transfer initiative and is the best funded (approximately $20 million/year).

Objective

NASA's objective is to expand alternative technology applications (spinoffs) from the wealth of technology NASA has developed to meet the aeronautical and space objectives of the past three decades.

Strategy

The program seeks to transfer its technology through four major mechanisms: fact sheets: NASA Tech Briefs, published in magazine format; electronic bulletin boards: the Tech Briefs are also published as an on-line database; information dissemination centers: Industrial Applications Centers, 38 information and consultation centers around the country; and decision tools: COSMIC, the NASA computer software center.

Results

Donald E. Bohringer, Argonne National Laboratory (ANL) engineering specialist, employed NASA information in two projects associated with the laboratory's Intense Pulsed Neutron Source (IPNS) facility, which is a powerful source of pulsed neutron beams for studies of the atomic and molecular structure of solids and liquids. The NASA technologies employed were improved vibration protection for a gamma ray detector and new leak detection technology. Both items appeared in Tech Briefs, a fact sheet publication that informs potential users of technology available for transfer.

Jet Propulsion Laboratory (JPL) had developed a package for gamma ray detectors that protects the detector's semiconductor crystal and isolates it from shock and vibration. ANL modified this JPL system to produce a new gamma ray detector. ANL also used Marshall Space Flight Center's documentation on the minimum leak rate to which soap solution detection is sensitive in the development of their leak detection system for vacuum and pressure vessels. The Marshall results determined the minimum to be less than one-tenth of the previously assumed minimum rate, a crucial design parameter to ANL.

NASA Industrial Applications Centers. NASA provided assistance to Stuart Snyder, president of Aqua/Trends, Boca Raton, Florida, who invented a family of computer-controlled Micro-Irrigation Systems, which systems are electronic controller programmed to dispense water according to the needs of the various household plants in an office suites, hotel lobbies, restaurants, lounges, banks and homes. He initially received information from the Southeast Area Office of the Southern Technology Applications Center (STAC), an information dissemination center, located at Florida Atlantic University, Fort Lauderdale, Florida. STAC furnished pertinent NASA technical reports, advised Snyder of seminars useful in product development, and put him in contact with NASA's National Space Technology Laboratories (NSTL), for technical assistance. NSTL conducts an ongoing research effort in plant use for water purification and pollution control and it made technical reports of this work available to Snyder. More than 100 Aqua/Trends systems are in service in the U.S.

NASA COSMIC Software Center. In the course of its varied activities, NASA makes extensive use of computer programs in such operations as controlling launch, analyzing data from spacecraft, conducting aeronautical design analyses, operating numerically controlled machinery, and performing routine business or project management functions.

NASA's mechanism for making such programs available to the private sector is the information dissemination center employing decision tools: Computer Management Software and Information Center (COSMIC). Located at the University of Georgia, COSMIC gets a continual flow of government-developed software and identifies programs that can be adapted to secondary usage. The Center's library contains more than 1,400 programs for such tasks as structural analysis, design of fluid systems, electronic circuit design, chemical analyses, determination of building energy requirements, and a variety of other functions. COSMIC customers can purchase a program for a fraction of its original cost and get a return many times the investment, even when the cost of adapting the program to a new use is included.

An example of how this service aids industry is the use of a NASA developed program in design of cogeneration systems. The Energy Systems Division of Thermo Electron Corporation, Waltham, Massachusetts, specializes in custom design of cogeneration systems. One element of Thermo Electron's computer system is a COSMIC-supplied software package called PRESTO, originally developed by Lewis Research Center to analyze the performance of regenerative superheated steam turbine cycles. It is a flexible program that can handle the specifications for most energy systems and can provide a realistic prediction of design efficiencies. The company estimates that $13,500 can be saved annually by using PRESTO.

Another example is the use of COSMIC's "best seller" NASTRAN (NASA Structural Analysis System) computer program by the University of Georgia. Originally developed by Langley Research Center for aerospace design applications, NASTRAN is a general purpose program that mathematically analyzes a design and predicts how it will stand up under the various stresses and strains it will encounter in operational service. This capability permits engineers to study the structural behavior of many different configurations before settling on a final design.

At the University of Georgia, students are being trained to use the NASTRAN system for a variety of new and different applications, including thermal analysis of agribusiness structures, nursery containers, and bins used for post-harvest handling of vegetables. The Agricultural Engineering Department reports that use of the NASTRAN program has encouraged student appreciation of numerical problem solving, and the department is planning additional applications of NASTRAN in its continuing program for teaching and applying sophisticated computer analyses.

GRI Technology Transfer Program

The technology transfer program of the Gas Research Institute (GRI) is comprehensive. To facilitate the commercialization (i.e., transfer) of technologies, GRI has implemented a well coordinated, multifaceted strategy.

Objective

The GRI was established in 1976 as a nonprofit research organization for the gas industry. Technology transfer is fundamental to GRI. The objective of its technology transfer program is to encourage private sector investment or redirection of private sector research programs. Its secondary objectives include transferring scientific knowledge, obtaining feedback from users, accelerating user acceptance, and developing and introducing new, efficient technologies. GRI is firmly committed to the commercialization of products and has monitored the benefits of its programs relative to the level of industry cofunding and royalty income.

Strategy

The organization of the GRI includes an Advisory Council whose members are selected from the National Association of Regulatory Utility Commissioners and other professional associations. Additionally, GRI management and research activities are reviewed by independent advisory committees that help direct GRI's R&D agenda towards real market needs.

GRI's technology transfer program revolves around the field testing of technologies to demonstrate the applicability of new technologies. GRI's research results are often cited in conference proceedings. GRI also disseminates findings through the National Technical Information Service and the patent application disclosure process.

GRI's research efforts usually involve multiclient projects and industrial exchanges. GRI provides technical assistance for state and local governments and conducts workshops and tours, technical forums, exhibits, and technology short courses.

GRI disseminates a wide array of publications to the public. Particularly noteworthy are The Grid (a technical journal) and Technology Profiles.

In each of GRI's three overall objectives--supply options, end use, and gas operations--and in GRI's crosscutting research, a technology transfer component is included in the project management process of all GRI programs. In addition to the technology transfer activities that are common to all programs, GRI tailors technology transfer activities for the unique features of specific technologies or project areas. For instance, GRI solicits a manufacturing partner early in the research phase when the immediate research objective is to develop a marketable environmental-control or safety product. For other research objectives, GRI selects project partners (e.g., trade associations) who can most effectively assist in disseminating project research results.

Maryland Energy Education Program

The Education Institute of the Maryland State Energy Office (SEO) conducts workshops for real estate professionals, architects, builders, developers, and home buyers. Topics include site planning and design for various regions of the state, general construction techniques, and cost-effective construction related to energy efficient design and superinsulation. The workshops are taught by a team of energy professionals representing the SEO, the University of Maryland Cooperative Extension Service, the City of Baltimore, Energy Works (a private consulting energy services company), and the host electric utilities.

Objective

The program of workshops is intended to inform construction industry professionals about new energy efficient homebuilding practices and other energy efficiency applications. The SEO also wants to enhance and accelerate use of the information, and to obtain user feedback.

Strategy

The program of workshops seeks to distribute as widely as possible the newest energy efficient technologies for homebuilding and energy use. The SEO utilizes several transfer mechanisms. The planning of the workshops is a collaborative effort involving state and local governments, utilities, the state university, and the private sector. Information is disseminated through the workshops. Additionally, workshops results are published in official trade publications such as the newsletters of professional real estate associations.

The SEO encourages feedback from the workshop participants. This two-way knowledge exchange assures that the newest and most efficient technologies are presented.

Results

The program of workshops has reached a large proportion of the desired audience with information about new energy efficient technologies related to housing. As a result, the program is expected to expand into additional workshops that focus on boilers, lighting, and energy conservation controls. These workshops will be developed primarily for facilities managers.

The SEO has learned that announcing the workshops by distributing brochures is less successful than writing to specific individuals. Attendance at the workshops has increased since the SEO changed to this highly targeted approach to attract the desired audience. The SEO has also learned that smaller, regional workshops are more successful than larger, centrally-located ones in reaching the largest audience.

Comments

The program of workshops is certified by the State real estate board. Real estate licensees who attend the workshops receive Continuing Education credits. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) has expressed an interest in co-sponsoring the workshop on boilers.

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