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Technology Transfer for DOE'S Office of Buildings and Community Systems: Assessment and Strategies

Marilyn A. Brown
Donald W. Jones
James O. Kolb
Sherri A. Snell

OPERATED BY
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EXECUTIVE SUMMARY

The U.S. Department of Energy (DOE) is the lead federal agency in discharging the overall legislative mandate for federal research and development (R&D) to assist the private sector in developing appropriate technology to conserve energy in buildings. The total effort, however, is a national undertaking and contributions to the national accomplishment, if they are to be significant, must come from industry with assistance from utilities and state and local agencies whose incentives, regulations, and policies shape the activities of industry. For the products of federal R&D to improve the energy efficiency of buildings, they must be utilized by industry and the public sector.

Technology transfer is viewed here as an ongoing government process of obtaining private sector and state and local government input into the development of R&D programs and of facilitating the use of R&D results by users. It is the part of the R&D process that brings together those conducting the R&D with those who can implement the results. The federal role in technology transfer is to ensure that the products of federal R&D are accessible to a broad spectrum of private- and public-sector interests in a timely fashion for maximum use and impact. To this end, this report discusses (1) the technology transfer problem faced by DOE's Office of Buildings and Community Systems (BCS); (2) a process for determining how to transfer specific R&D products of the BCS Office; and (3) the pros and cons of five prototype technology transfer strategies. The goal of the Office of Buildings and Community Systems is to increase the efficiency of energy use in the buildings sector. Thus, successful technology transfer is critical to its mission.

Technology transfer is a process of many discrete decisions and behaviors that unfold slowly over time. From the perspective of the producers of new technology, stages generally include: basic research; applied research; development; testing or evaluation; manufacturing or packaging; and marketing or dissemination. From the user's perspective, stages include: awareness; interest; evaluation; trial; adoption; implementation; and routinization. Unsuccessful attempts at technology transfer fail to proceed through the full range of producer and user stages.

The cost effectiveness of particular technology transfer activities depends upon many factors including:

- the nature of the R&D product being transfered;
- the audience being targeted; and
- the transfer mechanisms being employed.

Since the R&D programs of the Office of Buildings and Community Systems have a variety of products and audiences, they require individually-tailored technology transfer strategies.

The R&D programs of BCS involve diverse types of activities, including:

- long-range basic research;
- development of basic technology for products;
- product development;
- utilization and application research and techniques; and
- impacts research.

The products of these programs include both discrete technologies and disembodied technical information.

Audiences for BCS results are similarly diverse. Each product has a particular set of beneficiaries which may include primary, secondary, and tertiary audiences. For a tangible product, for instance, the primary audience is typically comprised of manufacturers, the secondary audience may be the associated retailers and building contractors, and the tertiary audience may be the ultimate consumer. Development of a product/market matrix is one of the first steps in developing a technology transfer strategy.

To transfer an R&D product to an audience segment, that segment must be understood in terms of its barriers and incentives to adoption and the information sources it relies upon most. Types of technology transfer barriers that have been recognized by building industry representatives and researchers include:

- legal constraints and barriers;
- institutional barriers;
- building construction industry barriers;
- information transfer barriers; and
- market barriers.

Next, appropriate transfer mechanisms need to be identified, and these can be summarized in a mechanism/audience matrix. While mechanism effectiveness is situation specific, this report offers an overview of a set of mechanisms in terms of their advantages, disadvantages, and appropriate situations for use. It also describes some of the institutional resources which can be capitalized upon in implementing a technology transfer effort. These resources provide vehicles by which general, consumer, or technical information can be disseminated, such as the National Technical Information Service, Conservation and Renewable Energy Inquiry and Referral Service, and the Office of Research and Technology Application. Other resources provide incentives and other support for technology transfer, including programs which affect end use (e.g., the Weatherization Assistance Program), provide support for the invention and innovation process (e.g., the Energy-Related Inventions Program), or encourage cooperative R&D (e.g., University/DOE Laboratory Cooperative Program).

After implementing one or more transfer activities, progress should be evaluated in order to judge their cost-effectiveness and adjust them as needed. Thus, a cycle is envisioned that begins with an assessment of needs, includes an implementation phase, and ends with evaluation and feedback.

Five prototype technology transfer strategies are described, each with its characteristic advantages, disadvantages, and situations for appropriate use. These five prototypes engage in activities which:

- target key decision-makers;
- engage in Laboratory/industry cooperative R&D;
- focus on innovators and leaders as industrial partners;
- work through trade and professional associations; and
- generate end-user demand.

"Targeting information and incentives to key decision makers" has the potential advantage of a higher response rate than an "untargeted" strategy or one which reaches less influential individuals. To effectively implement this strategy, knowledge of the decision processes and criteria of various market segments is necessary. A method of determining key decision makers and their decision criteria with respect to the design and construction of new buildings is described. Appropriate situations for this overall strategy are: (1) later stages of R&D or early stages of commercialization; (2) with technically difficult R&D results; and (3) when key decision makers are members of diverse audience segments.

"Engaging in laboratory/industry cooperative R&D" as a technology transfer strategy refers to cooperation with groups of industrial firms and other interested parties. It does not include work with single industrial partners. Cooperative arrangements can provide the organizational mechanism for structuring interactions and information exchanges between national laboratory scientists and industrial representatives seeking to use the R&D results. Industry involvement is usually most effective when initiated early in the R&D process. Types of cooperative R&D agreements include: (1) advisory boards and review panels; (2) cooperative research consortia; (3) R&D limited partnerships; (4) national user facilities; and (5) subcontracting. This wide range of cooperative R&D arrangements can cover the entire spectrum from research to commercialization, but is generally inappropriate for product-oriented R&D. Cooperative arrangements involving many industrial, university, and other collaborators appear to be most appropriate when:

- the technology is embryonic and the risks of cost-sharing are too great for a single company to bear;
- the R&D is not oriented to the development of new products but rather involves product testing or consumer use issues;
- the research has broad technological applications and will eventually affect two or more different industries or product lines;
- the ultimate market for a technology is large enough to support the involvement of many firms; and
- when companies in an industry are cash poor and need to join together to support R&D.

When one of more of these conditions is not satisfied, working with single industrial partners may be a better approach.

"Focusing on single innovators and leaders as industrial partners" capitalizes on the profit motive of private industry by offering nondisclosure agreements, patent rights, exclusive licenses, or other incentives to stimulate private investment in the commercialization process. Many factors are important in selecting an industrial partner, such as access to capital, an existing supply and product distribution system, and experience in developing and marketing new products. Ways of implementing this strategy vary across the stages of the R&D commercialization process; in particular, a transition from subcontracting to cost sharing and eventual full-cost recovery is suggested.

"Working with trade and professional organizations" capitalizes on the role of these organizations as brokers in the technology transfer process. These associations can serve as communication channels to bring R&D-related information to their various constituencies and to feed industry and end-user input into the R&D and technology transfer process. Since broker organizations vary considerably in terms of the resources they can bring to bear in the technology transfer effort, careful analysis and evaluation must be pursued in conjunction with any transfer effort relying primarily on them. The potential and actual use of broker organizations by the Office of Buildings and Community Systems are illustrated by: (1) the District Heating and Cooling Information Exchange of Argonne National Laboratory, and (2) the Roofing Program of Oak Ridge National Laboratory. The latter revealed an extensive and well-developed network through which collaborative R&D might be generated and R&D results on roofing systems could potentially be effectively disseminated.

"Generating end-user demand" focuses on the importance of market pull. Three situations are explored. Spinoff applications of BCS R&D results involve technology utilization for purposes other than those for which the technology was originally developed. A major step necessary to achieving this is identification of potential applications and associated markets. When a technology or product is actually adopted or used by consumers, it may be appropriate to enlarge consumer demand and improve implementation techniques through consumer information programs, establishment of adoption incentives, or reduction of barriers to use. Sometimes the introduction of a new technology hinges on a success story of key firms. Targeting key firms and then relying on a "diffusion effect" is likely to be most successful when: (1) the benefits of the technology are visible or easily documented and (2) investment performance is not highly variable across potential adopters.

The main body of the report ends with a discussion of several rules of thumb that cut across the individual needs of specific programs. An extensive appendix describes some of the institutional resources available to BCS to support its technology transfer activities, including names, addresses, and telephone numbers for further information on each of the programs.

1. INTRODUCTION

1.1 IMPORTANCE OF DOE/BCS TECHNOLOGY TRANSFER

The U.S. Department of Energy (DOE) is the lead federal agency in discharging the overall legislative mandate for federal R&D to assist the private sector in developing appropriate technology to conserve energy in buildings. The total effort, however, is a national undertaking and contributions to the national accomplishment, if they are to be significant, must come from industry with assistance from state and local agencies whose regulations and policies shape the activities of industry. To improve the energy efficiency of buildings, the products of federal R&D must be utilized by industry and the public sector.

For the purposes of this report, technology transfer is defined as an ongoing government process of obtaining private sector and state and local government input into the development of R&D programs and of facilitating the use of research results and other products by users. It is the part of the R&D process that brings together those conducting the R&D with those who can implement the results. The federal role in technology transfer is to ensure that the products and information of federal R&D are accessible to a broad spectrum of private- and public-sector interests in a timely fashion for maximum use and impact. To this end, this document discusses (1) the technology transfer problem faced by DOE's Office of Buildings and Community Systems (BCS); (2) a process for determining how to transfer specific R&D products of the BCS Office; and (3) the pros and cons of five prototype technology transfer strategies. The goal of the Office of Buildings and Community Systems is to increase the efficiency of energy use in the buildings sector. Thus, successful technology transfer is critical to its mission.

Technology transfer includes both mission-related activities (e.g., those related to energy conservation in buildings) as well as activities which generate secondary or spinoff applications of federal R&D. Secondary application refers to the transfer of federal R&D products to a user group other than the one for which the technology was originally developed. In general, the federal effort to stimulate secondary application is less coordinated than for mission-directed technology transfer, but both types are important.

It is generally accepted that technological and industrial innovations offer the potential for, among other things, an improved standard of living, increased public- and private-sector productivity, and creation of new industries and employment opportunities (Mansfield, 1968; Mansfield et al. 1982; Nelson, 1982). The discoveries and advances in science made in federal laboratories have been, and will continue to be the basis of many such innovations.

1.2 PAST FEDERAL TECHNOLOGY TRANSFER EFFORTS

Until the early 1960s, there was little interest in the transfer of technology from national laboratories to commercial use. There was no widespread consensus of a need to share federal R&D through marketing procedures, and technology transfer efforts were generally ad-hoc in nature. As a result, federal technology transfer initiatives received substantial criticism (O'Brien and Franks, 1981).

The major channels through which actively communicated information and ideas flow within and out of the federal laboratory system are informal professional networks. Such networks are generally restricted along disciplinary lines or according to areas of research interest, and do not tend to include practitioners or consumers. This form of outreach is highly effective as a means of interorganizational communication between basic and applied scientists and engineers. In particular, they can effectively transfer R&D results from national laboratories to researchers and professionals within large businesses, large research universities, research-intensive small firms, and those departments within local and state government agencies which have significant professional employment.

Federal agencies tend to rely on alternative modes of communication to reach audiences which are not part of the active research-oriented networks. Passive and reactive outreach mechanisms are relied upon, as typified by a number of computer based information banks and services sponsored by federal agencies. These data banks largely contain technical information and generally are available to anyone who can find out about them, know their content and cataloging characteristics, and who has the time and money to pay for them. Their effectiveness is hampered by, among other factors, the limitations of passive communications and the cost of searching through the data bases. Federal agencies rely on such passive information flow because of the high costs associated with active programs (Department of Commerce, 1984).

A tradition of highly successful technology transfer has developed within several federal agencies that have gone beyond these standard federal approaches. One of the earliest technology transfer programs operated by the U.S. Government is the Agriculture Extension Service program (Hough, 1975). Established in 1914 by the Smith-Lever Act, the Extension Service has been very effective in promoting the utilization of agriculture research results. The program consists of three main components:

- a research component involving state experiment stations and the U.S Department of Agriculture geared to producing "usable" research;

- county extension agents who act as "change agents," contacting farmers directly and indirectly through the media and the use of "opinion leaders;" and

- state extension specialists located in state agricultural universities, who link agricultural researchers to county extension agents.

Another program to foresee and capitalize upon the advantages and opportunities created by technology transfer was the National Aeronautics and Space Administration (NASA). The 1958 enabling legislation provided a clear technology transfer mandate, and NASA leadership saw promise in technology spinoffs being used as a selling point for funding further space exploration (Doctors, 1968). NASA's

Technology Utilization program includes selective dissemination of information services (e.g., NASA Tech Briefs), computer search services through regional Industrial Application Centers, a computer software service called COSMIC, and application teams which provide technical assistance to potential users of NASA's R&D. The National Aeronautics and Space Administration has found the greatest barrier to transferring technology to spinoff applications to be the identification of market applications.

Considerable interest has focused in recent years on the need for greater utilization of federal laboratory technology and expertise to increase the quality and efficiency of public sector services and to spur economic growth by private sector innovation. This need has been recognized in the creation of the National Science Foundation's Research Addressed to National Needs (RANN) project, and in policy statements by President Nixon in 1972 and President Carter in 1979. In addition, Congressional initiatives have sought to facilitate and encourage federal technology transfer through the passage of several key public acts. Today, technology transfer programs are common in federal research programs (Tornatzky et al., 1983).

Paralleling these trends, the process of technology transfer has received increasing scientific scrutiny in an attempt to identify generic principles that can help to improve the efficiency of transfer efforts. A multi-disciplinary tradition of research on the process of innovation diffusion and technological change has laid a valuable groundwork. Technology transfer programs have begun to capitalize on this knowledge by replacing ad hoc transfer efforts with systematic programs. Increasingly, technology transfer activities are based on an understanding of the needs of potential users of the R&D and the existing and projected market conditions.

Nevertheless, several dimensions of the technology transfer process are still poorly understood. Transferring products from producers to consumers, the realm of market research, is fairly well understood; but moving ideas from the laboratory bench to the producer is a different matter entirely, relatively ignored as a generic research question. As a special case, technology transfer from the public-sector research laboratory to producers in the private sector has been especially neglected.

1.3 APPROACH AND ORGANIZATION OF THIS DOCUMENT

In order to set priorities and allocate resources for technology transfer activities, it is necessary to develop some understanding of the probable costs and benefits of BCS expenditures on various types of technology transfer activities. This is a difficult task since the cost effectiveness of a particular technology transfer activity depends upon many factors including:

- the nature of the R&D product being transfered
- the audience being targeted;
- the transfer mechanisms being employed.

Since R&D programs have unique products and audiences, they need to develop and use individually-tailored technology transfer strategies. It is possible, however, to capitalize on similarities across programs by discussing "types" of strategies. To this end, we describe five prototype technology transfer strategies and summarize their characteristic advantages, disadvantages, and situations for appropriate use.

Each strategy can be conceptualized as a set of mechanisms used to link one or more R&D products to one or more audience segments ordered in time to capitalize on relevant dynamic effects. Figure 1.1 presents a diagram of hypothetical strategies designed to transfer four products of an R&D program. This diagram illustrates the diversity of strategy options available. Briefly, the first strategy engages in "laboratory/industry cooperative R&D." P_1 is a particular R&D product such as the results of performance testing of an insulating material. M_1 might be an industry review panel or some other mechanism through which a consortium of manufacturers and distributors is involved in the research effort. Leveraging occurs as the result of this strategy through the stimulation of consumer demand by manufacturers and distributers. The second strategy involves "industrial partners." P_2 might be the results of a product-oriented R&D effort aimed at placing a new energy-efficient building technology onto the market. M_2 might be a cost-sharing contract or some other mechanism through which a single industrial partner is involved in the R&D program. Once the product has reached the production stage, technology transfer activities are largely undertaken by the industrial partner which in this case typically has a strong incentive to promote adoption.

Figure 1.1 shows how two different strategies ("targeting key decision-makers" and "working through trade and professional organizations") can be used together to transfer an R&D product. For instance, communications or incentives concerning product P_3 could focus on one or more key decision-makers (in this hypothetical case, A/E firms and mechanical engineers); they could also capitalize on the brokering capabilities of trade and professional organizations. The fifth strategy, "generating end-user demand," seeks to increase the market pull for an R&D product (P_4) by reaching consumers (or other end-users) directly (as through a telephone hot-line or tax credits) or indirectly perhaps by capitalizing on the conservation programs of utilities.

This brief overview of five technology transfer strategies illustrates that there are many ways of stimulating use of an R&D product. By noting some of the advantages and disadvantages of each strategy, when it might be appropriate, and how to implement it, this report strives to make program managers better able to develop effective approachs for stimulating use of the products of their R&D programs.

One theme that unifies this report is the view of technology transfer as a process of many discrete decisions and behaviors that unfold slowly over time. As the process proceeds, people and groups are forced to select among alternative courses of action based on personal values and beliefs, costs, perceived risks, resources, availability, and other such factors. There are two major points of view from which stages are commonly described--the point of view of the producers of new technology or that of the user of the technology.

From the perspective of the producer or source of technology, stages generally include:

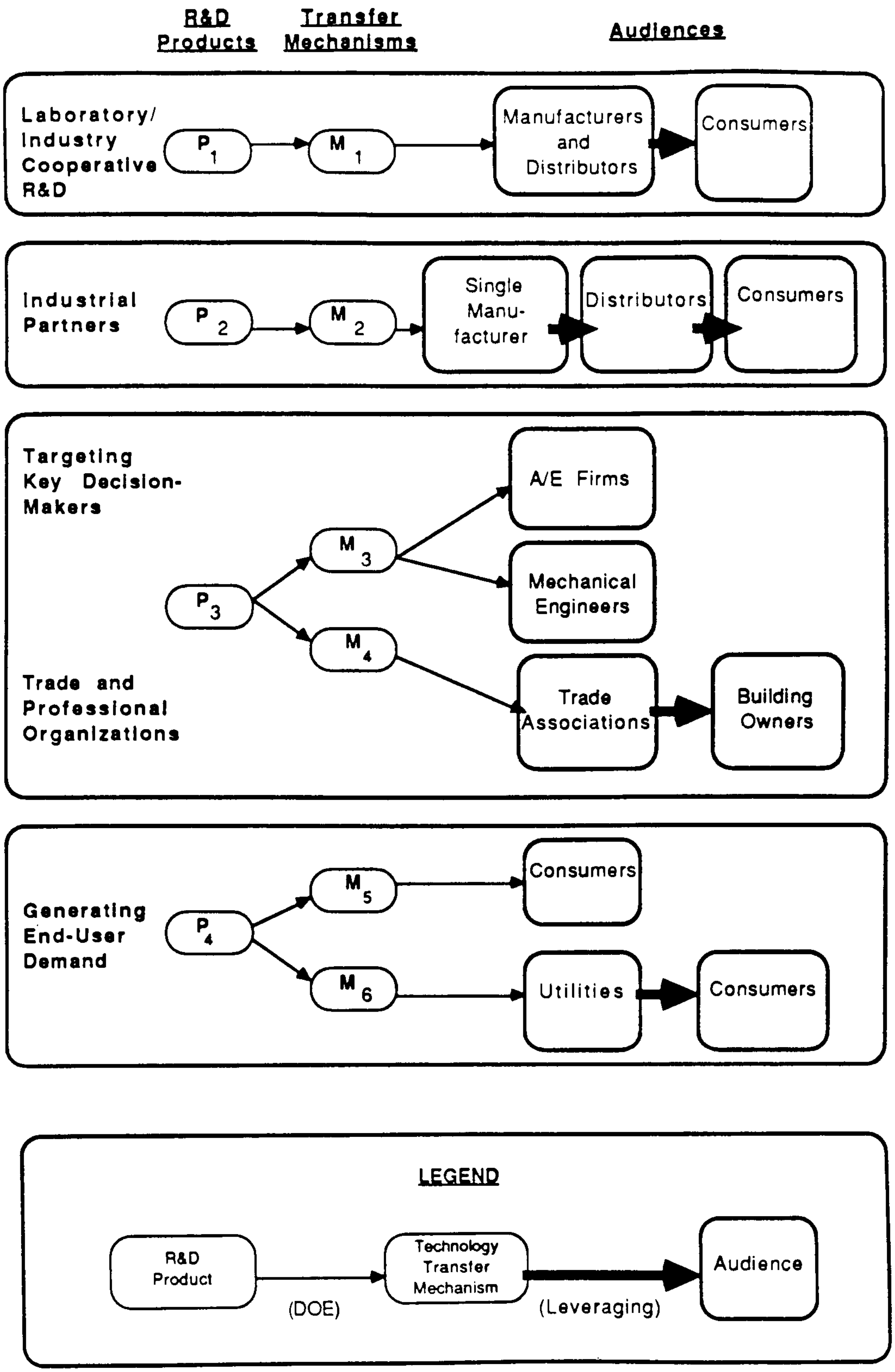

Figure 1.1. Prototype technology transfer strategies for BCS R&D.

<u>Research</u>
(1) basic research
(2) applied research
<u>Development</u>
(3) development
(4) testing or evaluation
<u>Commercialization</u>
(5) manufacturing or packaging
(6) marketing or dissemination

As these stages proceed, the technology becomes defined with greater specificity. At the conclusion one has a definite item in hand that has been introduced to the market.

The user model begins with the stages applicable to potential adopters of the technology and includes:

(1) awareness
(2) interest
(3) evaluation
(4) trial
(5) adoption/commitment
(6) implementation
(7) routinization

In general, the producer stages occur before the user stages, but not inevitably. Critical interactions may occur between sources and users which guide the development of particular technologies (e.g., von Hippel, 1979). We will return to these interactions and other aspects of the stage models as the report unfolds.

Chapter 2 discusses the organization of DOE's Office of Buildings and Community Systems, the types of R&D products that BCS is attempting to transfer, the audiences for BCS R&D results, and the audience segmentation process. Chapter 3 provides information on the types of transfer mechanisms available to BCS and the strategy development process. Chapters 4 through 8 describe each of the five prototypical strategies and illustrates them using examples from BCS programs. The report concludes by offering broad recommendations for future BCS technology transfer efforts.

2. OVERVIEW OF THE BCS PROGRAM, ITS R&D PRODUCTS AND ITS AUDIENCES

2.1 OBJECTIVES AND PROGRAM OVERVIEW

The goal of the Office of Buildings and Community Systems (BCS) is to advance technologies that will increase the energy efficiency of buildings. This goal is achieved, in part, through a comprehensive research program that increases the scientific and technical options available to reduce building energy loads, increase efficiency of energy use, facilitate the substitution of more plentiful fuels for scarcer fuels in buildings, and promulgate legislatively mandated regulations for decreased loads and increased efficiency. Achievement of the BCS mission also requires transfer of the result of BCS research to users in the private and public sectors.

The Office of Buildings and Community Systems operates five research programs through four functional divisions, as shown in Figure 2.1. The five research programs are:

- o Building Systems
- o Community Systems
- o Technology and Consumer Products
- o Appliance Standards
- o Analysis and Technology Transfer

2.1.1 Building Systems

Building Systems research seeks to advance the basic scientific, engineering, and architectural understanding of energy use in buildings. This program area also is responsible for meeting the Congressionally-mandated requirements for Energy Conservation Standards and Guidelines for New Buildings. Building systems research is organized under five broad areas.

Building Materials Research supports studies of basic physical, chemical, and mechanical properties of insulation and other building materials which influence their effectiveness, durability, safety, and health impacts when used for energy conservation.

Building Subsystems Research advances the scientific and technical understanding of the energy performance of the basic features of buildings including walls, roofs, and windows. It also conducts research on the movement of air through the building envelope and within the building including infiltration and ventilation and their effect on indoor air quality.

Building Systems Integration takes the results of research on building subsystems and components and integrates them so as to optimize the energy performance of whole buildings.

Building Retrofit Research focuses on the special problems associated with improving the energy performance of the nation's existing stock of buildings. It seeks to determine the most cost-effective retrofit strategies based on actual field experience, and to quantify the impacts of retrofit quality and occupant behavior changes on energy savings.

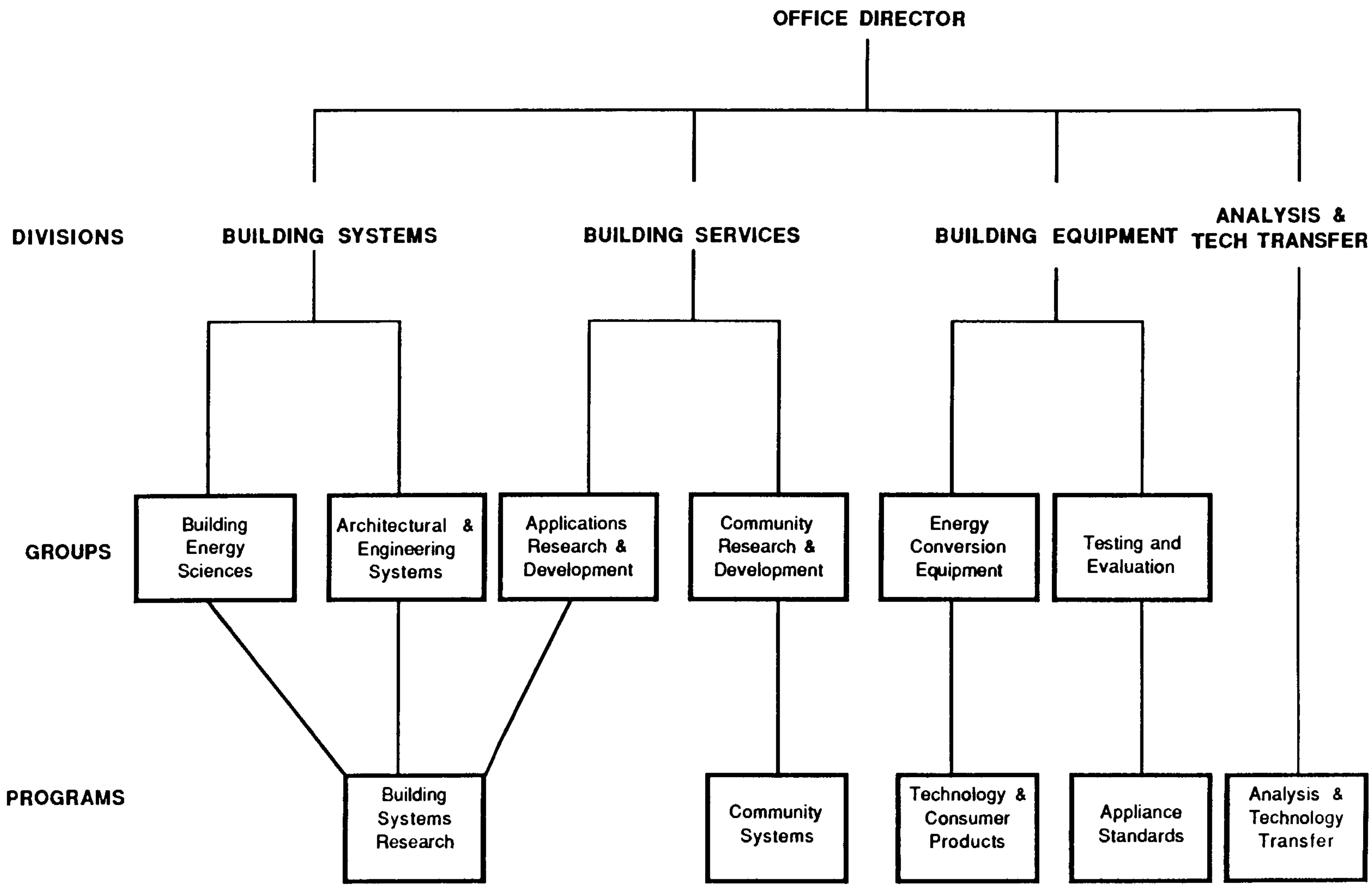

Figure 2.1. Organization of the BCS R&D program.

The Energy Conservation Standards and Guidelines activity is designed to meet both statutory requirements and the needs of the buildings industry for energy efficient building guidelines.

2.1.2 Community Systems

The Community Systems program provides the technological basis for improved efficiency in the production, delivery, and use of energy at the community level. The program conducts research on district heating and cooling systems and components, and on community-wide energy planning and management systems in cooperation with the private sector, state and local governments, and other federal agencies.

District Heating and Cooling (DHC) Development supports research to improve the cost-effectiveness of DHC systems and components and to augment the use of local energy resources in such systems. Activities include the development of low-temperature resource systems, lower-cost piping systems for distributing heat, and analytical tools to determine the feasibility of DHC systems.

Community Energy Planning, Development, and Management provides assistance to increase energy efficiency in local government facilities and services, community land-use decision-making, and the matching of local energy supply and demand requirements.

2.1.3. Technology and Consumer Products

This program conducts research on basic processes, materials, and phenomena related to advanced heating, cooling, lighting equipment, and appliances for buildings. The program expands the scientific knowledge of the technologies on which heating, cooling, and lighting are based. It has five subprograms.

The Thermally Activated Heat Pumps subprogram engages in testing and evaluation of advanced absorption heat pump cycles and has conducted basic research into the technology of novel absorption fluids, including physical property data, heat and mass transfer, corrosion, and stability.

Refrigeration Technology focuses on generic research on heat and mass transfer in ground-coupled heat exchangers, composition control techniques for non-azeotropic refrigerants, heat pump dynamic loss characterization, novel appliance insulation concepts, and commercial building equipment system concepts.

Combustion Systems supports research on condensing heating systems, development of combustion diagnostics and models for wood combustion.

Equipment Integration focuses on the impact of advanced lighting systems on the health and productivity of building occupants and equipment, the interaction of lighting systems on HVAC and envelope systems, and thermal distribution systems.

The Light Sources subprogram supports basic research on plasma discharge phenomena, advanced engineering research on high-frequency, electrodeless lamps, and research on the building application of advanced lighting techniques for buildings.

2.1.4. Appliance Standards

The Appliance Standards program is responsible for meeting statutory requirements that DOE develop test procedures for measuring the energy efficiency of 13 household appliances and determine whether mandatory energy efficiency standards would save significant amounts of energy and be economically justifiable.

In the Appliance Testing and Labeling subprogram, rules are developed for appliance testing, based on research performed to improve test procedures.

Appliance Standards involves development of rules on state petitions for exemption from federal energy efficiency standards, based in part on analytic studies of appliance standards.

2.1.5. Analysis and Technology Transfer

This program provides planning and analysis for the entire BCS program. It provides the coordination and synthesis functions necessary to manage as a cohesive overall program the many diverse technologies developed by the Office of Buildings and Community Systems. This program also provides support for strategic planning, management, and implementation of technology transfer activities across BCS.

2.2 TYPES OF BCS R&D PRODUCTS

The products of BCS R&D programs include both discrete technologies and disembodied technical information. In fact, the major products of BCS and other federal programs tend not to be discrete technologies but accumulated technical information and expertise. This situation is reflected in the low patent to federal R&D investment ratio as well as the small number of federal patents licensed to the private sector (Department of Commerce, 1984, pp. 20-21). The fact that many energy-related problems within the buildings industry are solvable through technical assistance rather than novel technologies, suggests that a technical assistance component of technology transfer is necessary. Indeed, the Stevenson-Wydler Technology Innovation Act of 1980 mandates a technical assistance component to the laboratory-level technology transfer effort.

Another way of categorizing the R&D products of the Office of Buildings and Community Systems is offered below.

- long-range basic research
- development of basic technology for products
- product development
- utilization and application research and techniques
- impacts research

Attention will return to these five categories of R&D products since they tend to differ in terms of the audiences which can potentially use the products and the strategies which work most cost effectively.

2.3 AUDIENCES FOR BCS R&D RESULTS

The audiences for BCS R&D results are extremely diverse. They are divided into six broad categories and 30 subcategories in Table 2.1. Further levels of classification are possible and indeed desirable when developing a technology transfer strategy for a particular R&D project or product.

2.3.1 Designation and Analysis of Target Audiences

Each BCS R&D program, and each of its products, has a particular set of beneficiaries. For example, when developing a tangible good, the primary audience is a set of manufacturers--those who are potentially willing and able to develop and produce the good. At the same time, there may be secondary audiences--the intermediaries--who can be used to help transmit or reinforce the technology transfer effort. For instance, the intermediaries may help direct and/or distribute the product from the manufacturer to the ultimate consumer, and could include retailers, utilities, lenders and appraisers, building code officials, construction or building contracting firms, or trade associations. The tertiary market for the tangible good, the end-users, may be individuals, non-profit organizations, state or local government agencies, or firms.

While the various R&D programs sponsored by BCS have their own unique sets of audiences, there appears to be a close relationship between types of R&D product and audiences. Using the classification of R&D products presented previously, the following general relationships are suggested:

R&D Product:	Audience Segment:
long-range basic research	scientific community
development of basic technology for products	manufacturers
product development	manufacturers and distributors
utilization and application research and techniques	regulators, manufacturers, implementors
impacts research	implementors and consumers

One way to depict clearly the relationship between R&D products and audiences is to develop a product/market matrix. Table 2.2 provides an example based on LBL's Windows and Daylighting Program, in which four products (the columns) are matched with eleven audience segments (the rows) in terms of level of interest. Level of interest reflects the closeness of fit between product characteristics and audience needs and desires; as such it also measures an audience's potential for adoption of the energy-efficient technology.

Table 2.1 Audience Segments of DOE's Office of Buildings and Community Systems

1. <u>Industry Professionals & Their Organizations</u>

   A. Developers
   B. Home Builders and Contractors
   C. Building Owners & Managers
   D. Architects & Designers
   E. Engineers
   F. Building Tradespeople
   G. Realtors

2. <u>Manufacturers and Distributors</u>

   A. Building Products & Materials Manufacturers & Distributors
   B. Manufacturers and Retailers of Manufactured Homes
   C. Solar/Renewable Resources Industry
   D. Building Equipment & Component Manufacturers & Distributors
   E. District Heating & Cooling Industry

3. <u>Energy Supply, Production, Service Industry & Their Associations</u>

   A. Natural Gas Utilites
   B. Electric Utilities
   C. Home Heating (Oil, Propane, LPG) Suppliers
   D. Energy Service Companies

4. <u>Government & Its Organizations</u>

   A. Federal Agencies
   B. State Agencies
   C. Local Governments Agencies
   D. Standards, Codes, & Specifications Specialists
   E. Urban and Community Planners
   F. Public Service Commissions & Governor's Offices
   G. State Energy Offices

5. <u>Researchers and Educators</u>

   A. College & University Researchers & Educators
   B. National Laboratory Researchers
   C. Industry Researchers

6. <u>Others</u>

   A. Lenders, Financiers, & Appraisers
   B. Public Interest Groups
   C. Consumers
   D. International Audiences

Table 2.2 A product/audience matrix for LBL's windows and daylighting programs[a]

Audience segments:	R&D products: Optical materials	Components and systems	Performance in buildings	Impacts
Industry/manufacturers (e.g., building materials and component suppliers, optical material firms)	●	●	o	o
Industry organizations (e.g., NFC, AAMA)	o	●	●	●
Architects/engineers (e.g., AIA, ASHRAE, IES)		o	●	●
Educators/universities (e.g., daylighting network)		o	●	o
Utilities (e.g., PG&E, EPRI)	o	o	●	●
Standards organizations (e.g., ASHRAE 90)		o	●	●
Policy makers (e.g., CEC, FTC)		o	o	o
Government agencies (e.g., DOD, GSA)			●	o
Researchers (e.g., national labs, IEA)	●	●	●	o
Government research groups (e.g., Canada NRC)	●	●	●	o
Publishers/authors (e.g., N.Y. Times, Solar Age)	o	o	o	o

[a]● indicates major interest, o indicates some interest, and a blank indicates little or no interest.

Source: Revised from material presented at an LBL program review for BCS.

To effectively transfer R&D results to these audience segments, each segment should be understood in terms of its various characteristics. For instance, size of the audience segment (e.g., number of manufacturers or retailing establishments) is important in determining the viability of contacting each member personally versus using intermediaries or mass marketing approaches. Knowledge about industry structure (including the concentration of sales or employees among the few largest firms) is also useful in deciding whether or not to concentrate transfer activities upon a few large and possibly influential members. As one example, consider the following four audience segments:

Segment:	Size:
architectural educators	3000
schools of architecture	93
individual architects	65,000
architectural firms	18,000

(Source: Watts, et al., 1985)

The small number of architectural educators and schools of architecture suggest that active and personal communications using such mechanisms as targeted mailings and conferences are feasible. The large number of individual architects and architectural firms (and the fact that the vast majority of architectural firms have 10 or fewer employees) suggests that a more reactive mode may be necessary, relying perhaps on computer-based information banks and services.

An understanding of the audience's attitudes and knowledge and its reliance on different information sources also helps in the development of an effective approach. To ensure that future R&D products meet the needs of these audiences, it is also important to understand the energy-related problems they face and their research priorities.

2.3.2 Needs Assessments

Activities aimed at better understanding market conditions are often called "needs assessments." At a minimum, needs assessments must take into account the federal government's role, ongoing technology transfer activities, and the likely impact of additional R&D and transfer efforts. A needs assessment may be general in nature, aimed at determining overall priorities for the BCS program, or it may be specific and targeted to a narrow technical area or market segment.

In the past, BCS has sponsored several general needs assessments. For example, Eichenberger (1984) describes a BCS-supported activity aimed at soliciting building energy research needs from 12 major building industry organizations. Each organization was asked to provide information concerning three to seven research needs. The assessment found that more than one-third of the industry needs are matched by existing federal building research activities; one-fourth of the needs have no counterpart among existing federal R&D; and the balance of the needs have only a limited counterpart among existing federal research efforts. These findings highlight the important opportunity that exists for building industry organizations and BCS to exchange information about present and future research needs and activities to ensure that the results of federal R&D satisfy industry requirements.

The 1984 Technology Transfer Roundtable sponsored by BCS is another example of a general needs assessment (ASHRAE, 1985). In this instance, the focus was on technology transfer needs. The Roundtable brought together representatives of some 25 trade and professional associations and individual firms in the buildings industry with researchers from industry and government laboratories. The objectives were: (1) to examine and critique the technical information transfer procedures now in use by these organizations; (2) to identify constraints, discontinuities, limitations, and inadequacies in the presently used technology transfer processes in the building community; and (3) to recommend new or improved procedures for alleviating inadequacies in the technology flow process. Recommendations of the Roundtable are summarized in Table 2.3 and are addressed in subsequent sections of this plan.

More specific, targeted needs assessments may focus on (1) a single technology, in order to better understand and overcome barriers to its adoption, or (2) a particular audience segment, in order to better transfer technologies to it (a primary or tertiary audience) or with its assistance (a secondary audience). The Office of Buildings and Community Systems has supported a few such needs assessments. For instance, a "Colloquium on Automatic Daylight Controls" was held in 1985 to aid in the understanding of factors underlying the resistance of the office building construction industry to the use of automatic daylight controls. It included building owners, operators, manufacturers, architects, engineers, and federal research laboratory representatives and resulted in an action plan which has been partially implemented.

Needs assessments help refine the product/market matrix and develop appropriate transfer strategies. A preliminary list of audience segments may be too diverse in their needs and practices to be effectively served. Further segmentation can help to identify those distinct subsets of beneficiaries to be specifically targeted. The market segmentation or partitioning is performed by defining audience segments according to criteria such as geographic location, firm size, product line, and distribution network.

Appropriate segmentation criteria will vary across R&D products. In each case the criteria should divide the audience into segments which have distinct differences in the ways they relate to an R&D product, that is, the segments should exhibit homogeneity within and heterogeneity between groups. The segments should also be large enough to be worth the effort of differentiating the market.

For owner-occupied dwellings, relevant segmentation criteria include the household head's age, income, and education. Barriers and incentives to adoption differ according to these variables, and explain why greater adoption of energy-conserving ideas and products is generally found among individuals who are younger, wealthier, and better educated (Warkov, 1978; Brown and Rollinson, 1985). For

Table 2.3 Recommendations of an Industry Technology Transfer Roundtable

Low cost

1. DOE should become familiar with the processes of handbook revision and how technical information gets incorporated into these handbooks and should make research results available to the authors of these handbooks.

2. DOE should contribute articles to the journals which designers read to obtain the latest technical information.

3. DOE should identify an information expert to interface with design journal editors.

4. A building industry directory should be developed that would identify researchers and organizations with research projects or subjects.

5. All research reports should include a summary, one or two pages in length. these summaries should be in a standard format for ease of the reader in using, filing and seeking more detailed information

6. A consensus numbering system for building research subjects should be developed. The current system used by CSI and Sweets might be used.

7. Research reports should be condensed to provide only salient information.

8. An annual conference on technology transfer should be held to emphasize the importance of converting research results into design practice.

9 DOE should introduce technology transfer objectives into the planning, justification and management of research programs.

10. DOE should develop and improve direct working relationships with building industry associations and professional societies.

Moderate cost

1. DOE personnel should become active in introducing research results into new editions of the four most used handbook series.

2. DOE should concentrate on transferring research results to building product and assembly manufacturers for distillation into design-type information.

Table 2.3 Recommendations of an Industry Technolgy Transfer Roundtable (cont'd)

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3. DOE should support research at universities where research can be immediately incorporated as an educational tool.

4. DOE should cooperate in developing and presenting a series of workshops for IES chapters and for other technical areas directed toward the design professions.

5. All research programs should be subjected to review by knowledgeable and objective peers.

6. The past research output of BCS should be compared with program recommendations of the Carmel reports and the National Program Plan for completeness and cost-effectiveness.

7. DOE should adopt a market-oriented approach in planning, monitoring, evaluating and implementing research, combined with a strong effort to stimulate market demand for energy conservation.

8. DOE should significantly increase funding for technology transfer and research utilization.

9. DOE should strengthen its relationships with institutions of research and education.

10. Federal agencies should consider the use of voluntary consensus standards as a mechanism for technical information transfer and elevation of general industry practices.

High Cost

1. DOE should organize and support a group of professionals to distill research results and reformat them into design practice.

2. DOE should support design leaders to bring research results from concept to design practice through "proof of concept" projects.

3. DOE should cooperate in the effort to convert handbook data to a computer data base.

4. A system for advertising research results should be developed and implemented.

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commercial buildings, ownership type (e.g., owner-occupant vs. investor-owner) and mode (e.g., corporate/franchise vs. developer/speculator ownership) are key segmentation criteria because they separate owners with distinct incentives for energy conservation. When targeting information to practitioners responsible for the design and construction of buildings, segmentation can be according to the types of opportunities for energy efficient technologies affected by different types of practitioners (e.g., developers, builders, contractors, architects, etc.).

By addressing the different characteristics possessed by market segments, a more successful transfer to the targeted population can be accomplished.

3. TECHNOLOGY TRANSFER MECHANISMS AND STRATEGIES

3.1 TRANSFER MECHANISMS--CHARACTERISTIC ADVANTAGES, DISADVANTAGES, AND SITUATIONS FOR USE

The technology transfer process is carried out via transfer mechanisms--activities directed at stimulating use by public- and private-sector audiences. Such mechanisms include various types of information transfer (e.g., presentations at conferences, publications, and exhibits), means of conducting cooperative R&D (e.g., researcher exchanges and industry review panels), and provision of incentives (e.g., cost-sharing arrangements and grants for technology feasibility studies). Each mechanism has its own characteristic advantages and disadvantages. As a result, combinations of mechanisms have been found to be the most effective manner of stimulating the use of R&D products.

Types of communications used to transfer technical information can be characterized as active or passive and as such have distinct pros and cons. Active communications involve person-to-person interactions. Passive communications are non-personal and involve mass media such as: radio, television, or newspapers; more selective written forms such as journal articles or trade magazine publications; or nonreactive verbal communications such as lectures to large groups. Mass channels are aimed at large, undifferentiated audiences, while selective written material is more specialized in reach and focus.

For comparison purposes, Table 3.1 rates personal and non-personal communication channels on several dimensions. Channels vary as to the amount of information carried, the accuracy of the information content, and the degree to which the information is specific or technical. Certain channels serve primarily to assure awareness of an R&D result, while others emphasize details about a technology such as availability and price. Both personal and impersonal channels may serve an awareness function or provide details about a technology, but personal channels are most effective in modifying attitudes and generating adoption and sustained use.

Some degree of active, personal communication is called for under the following circumstances:

- information must be tailored to the specific needs of individuals;
- a continual exchange of information is needed to ensure that the correct problem is being addressed, and that answers required at different stages in the transfer process are provided; and
- personal interaction is needed to build trust.

These conditions are frequently present when attempting to transfer complex new energy-saving technologies.

Table 3.1 Personal vs. Non-personal Communication Channels

Characteristic	Channel type and rating: Non-personal	Personal
Audience size	Large	Small
Spatial extent of coverage	Large to moderate	Small
Message uniformity	High	Moderate to low
Amount of information	Low	Moderate to high
Accuracy of information	High	High to low
Specificity of information	Low to moderate	Moderate to high
Audience selection ability	Low to moderate	High
Message customization	Low to moderate	High
Usage to create awareness of the innovation	High	Low
Usage to bring about adoption	Low	High

Source: Semple, Brown, and Brown (1977)

The effectiveness of transfer mechanisms is situation specific and depends upon a host of factors, some of which are described below.

- <u>budgetary constraints and options.</u> A reduced budget may require that expensive transfer activities be curtailed in favor of more affordable mechanisms.

- <u>policy environment.</u> Policy concerns may affect the choice of technologies, audiences, and mechanisms. For instance, liberal or conservative approaches to market intervention by federal agencies are affected by political considerations.

- <u>characteristics of the technology.</u> If a technology is particularly complex, then specialized training mechanisms may be required. If the technology is risky or requires high fixed costs, then particularly persuasive mechanisms may be required.

- <u>audience/industry characteristics.</u> If numerous small companies must be reached, then mass approaches may be more appropriate than when few key actors exist. Technical publications are more appropriate for an audience of researchers versus consumers.

- <u>the institutional/economic environment.</u> External economic factors such as the price of energy and the cost of credit affect incentives to adopt energy-saving technologies and make it necessary to employ more or less persuasive transfer mechanisms. Legal constraints on the ownership of patents affect the ease with which industry collaboration in R&D programs is possible.

Table 3.2 summarizes principal advantages and disadvantages of some commonly employed technology transfer mechanisms and suggests appropriate situations for their use. Figure 3.1 suggests transfer mechanisms for specific audiences.

One way to decide upon the mechanisms appropriate to a particular situation is to employ a two-step approach. First identify those mechanisms which are most effective for each of the audience segments to be reached. This information can be organized in a matrix format, as in Table 3.3. The mechanism/audience matrix shown in this table was developed for ORNL's Building Equipment Research Program. It identifies three audience segments: manufacturers--who can be seen as a primary audience; consumers--who can be seen as a tertiary audience; and utilities--who act as a secondary audience or intermediary. Note that for each of these audiences several different mechanisms are used. For instance, consumers are the recipients of printed material and workshops, while utilities are reached through trade asociation activities and informal information exchanges.

Second, select from among the entries in the matrix, those mechanisms which are most applicable to the R&D product in question. Using the same example from Table 3.3, if the R&D product is results of performance testing on a new electric appliance, technical papers may be more appropriate than workshops to reach manufacturers (due to the

MECHANISMS	ADVANTAGES	DISADVANTAGES	APPROPRIATE SITUATION
•WORKSHOPS/SEMINARS/ CONFERENCES	•Inexpensive •Assembles key decision makers •Promotes discussion, interaction	•Difficult to follow up	•All stages of technology development. The smaller workshops and seminars tend to be most useful for specific topics. Conferences are most useful for subjects with broad appeal.
•TECHNICAL ASSISTANCE/ EDUCATION/TRAINING	•Direct and immediate •Promotes second generation technology transfer •Can achieve long-term behavioral change	•Highly selective •Expensive	•There is a Nationally recognized need •Complex information needs to be conveyed and illustrations/demonstrations are essential
•VISITS TO/FROM INDUSTRY	•Key actors meet one-to-one •Inexpensive •Promotes personal interaction •Rapidly accomplished •Technical dialogue excellent	•Highly variable pay off	•Technology is visible or impressive and key actors need convincing •All stages of technology development
•PERSONNEL TRANSFER TO/FROM INDUSTRY	•No training lag •Minimal agency effort or expense •Shared costs and risks	•Possible loss of key personnel •Subject to availability of personnel •Short-term loss to agency/industry •Cost of administrative arrangements	•Information exchange requires extended personal interaction •Inventor can assist in implementation/manufacture of a new technology
•SUBCONTRACTS AND COOPERATIVE R&D	•Early interaction with private sector •Reduces private sector risk •Rapid technology transfer •Gains access to enhanced resources •Overcomes "not invented here" syndrome	•Potential interference with private sector •Potentially discriminatory to competing companies	•Government and industry goals and needs match •Technology is feasible, yet untested

Table 3.2. Transfer mechanisms: characteristic advantages, disadvantages, and appropriate situations for use.

MECHANISMS	ADVANTAGES	DISADVANTAGES	APPROPRIATE SITUATION
•RADIO/ TELEVISION ANNOUNCEMENTS	•Reach a wide audience •Rapid receipt of message	•Impact is likely of short duration •Expensive •Likely to be superficial •Ineffective in changing strongly held attitudes	•There is a need to generate awareness by a broad audience quickly
•VIDEO TAPES	•Highly informative •Reach wide audience •Flexible use •Easily edited and updated	•Must establish a distribution network •Expensive	•Complex information needs to be conveyed and illustrations/demonstrations are essential
•TAX INCENTIVES/ LOAN GUARANTIES	•Reduces private sector risk •Enhances private initiative	•Potential loss to Treasury •May raise interest rates •Secondary effects may outweigh intended effects	•Well developed technology that has not yet gained public acceptance
•GUIDELINES AND STANDARDS	•Adds credibility to new products •Provides basis for comparing products	•Lengthy time to establish •Outdated standards may inhibit use of new technologies	•Individual evaluation of products is difficult •Well developed technology that has not yet gained public acceptance
•COMPUTER SOFTWARE AND OTHER DECISION TOOLS	•Simplifies the communication of complex information	•Necessary computer software may be expensive to develop •Traning may be necessary	•Complex information needs to be considered in decision-making in order to generate demand for energy-efficient technologies
•COMPUTER NETWORK	•Rapid information exchange	•Necessary computer hardware may be expensive to purchase	•An ongoing exchange of technical information is necessary

Table 3.2. Transfer mechanisms: characteristic advantages, disadvantages and appropriate situations for use (cont.).

MECHANISMS	ADVANTAGES	DISADVANTAGES	APPROPRIATE SITUATION
•INDUSTRY ADVISORY COMMITTEES	•Promotes government/ industry communication •Provides R&D direction •Inexpensive •Easy to administer •Can be helpful as program advocates	•Vulnerable to special interest pressures •Vulnerable to conflicts of interest •Proprietary interests may discourage information sharing •Non-proprietary information sharing may discourage product development	•All stages of technology development
•DIRECT MAILING (Newsletters, Information packets, brochures, fact-sheets)	•Effective in generating awareness •Reach widespread audience •Rapid receipt of message •Information dissemin-ation does not require major user effort	•Communication is not interactive and runs the risk of not providing desired information •Depth of information covered tends to be limited by the format	•There is a need to generate awareness by a broad audience quickly
•TECHNICAL REPORTS AND PUBLICATIONS IN PROFESSIONAL JOURNALS, TRADE MAGAZINES	•Tangible, permanent documentation •Can be tailored to an identified audience •Inexpensive	•No personal contact	•Addressing scientific and practitioner communities throughout the stages of technical development •When a specific problem/ solution has been identified
•NEWS RELEASES	•Reach widespread audience •Inexpensive	•Likely to be superficial	•There is a need to generate awareness by a broad audience quickly
•INFORMATION DISSEMINATION CENTERS	•Provide responses quickly "on demand" •Referral services may be available •Easy access to information •Tailored responses to specific questions	•Typically passive, must await requests •Quality dependent on collection and currency	•Addressing broad, large audiences at later stages of technical development
•BANKS OF ENERGY PERFORMANCE DATA	•Interagency and international capabilities •Easy access to information	•Passive, must await requests •Can be inaccurate or incomplete •May not be current	•When a technology is at an active R&D stage and further development is dependent on data assimilation and analysis

Table 3.2. Transfer mechanisms: characteristics advantages, disadvantages, and appropriate situations for use (cont.).

Transfer Mechanisms (Numbers reflect degree of costliness and difficulty)

Audiences	Newsletter 3	News Release 1	Press Briefing 2	Feature Article, Trade/Professional 1	Feature Article, Popular Press 1	Television Appearance 4	Radio Interview 3	Educational Film 5	Technical Brochure 2	Full Technical Report 1	Technical Monographs 2	Technical Briefing 3	Technical Slide Presentation 2	Technical Fact Sheet 1	Technical Exhibit 5	General Brochure 1	General Slide Presentation 1	General Exhibit 5	Videotape 5	Personal Letter (High-Level) 1	Personal Letter (Program-Level) 1	Speech (High-Level) 1	Speech (Program-Level) 1	Presentation (Non-DOE) 1	Design Award and Documentation 3
Owner/Occupant Developers				●	●	○	○									●									
Commerical Building Developers	○	○		○	●	○	○						●	●	○	●	●	●		●	●	●	●		●
Residential Building/Developers	●	○		○	●	○	○							○		●				●	●	●	●	●	●
Commercial Building Financiers	○	○		○	●	○	○							○		●						●	●		
Residential Building Lenders	○	○		○	●	○	○							○		●						●	●		
Architects	●	●		●	●	○	○	○	●	○	○	●	●	○	●	●	●	●	○	●	●	●	●	●	●
Professional Engineers	●	●		●	●	○	○	○	●	○	○	●	●	○	●	●	●	●	○	●	●	●	●	●	●
Residential Realtors	○	●		●	●	○	○				○					●				●		●	○	○	○
Commercial Realtors		●		●	●	○	○				○					●				●		●	○	○	○
Building Product Manufacturers	○	○		○	○	○	○							○		●		○							
Building Product Distributors	○	○		○	○	○	○									●									
Energy Utility Companies	●	●		●	●	○	○		●	●		●	○	○		●	●			○	○	●	○	○	
Building Code Officials	●	○		●	○	○	○		●	●	○	○	○	○	●	●	●			○	○	●	●	○	
Model Building Code Groups	●	○		●	○	○	○		●	●	●	●		○		●	●			○	○	●	●		
Consumer Interest Groups	●	●		○	○	●	●	○				○	○			●	○	○		●	○	●	●	●	○
Environmental Interest Groups	●	●		○	○	●	●	○	○			○	○			●	●	○		●	○	●	●	●	○
Renewable Energy Resource Groups	●	●		○	○	●	●	○	○		●	●	○			●	●	○		●	○	●	●	●	○
Trade and Professional Technical Writers	●	●	●		●	●	●		●	●	●	●	○			●						●	●	○	○
Home and Real Estate Section Writers	●	●	●		●	●	●									●						●	○	○	○
National Popular Press Writers		○	●		●	●	●									●						●	○	○	
Association Newsletter Writers	●	●	●		●	●	●									●						●	○	○	○
Administration Policy Staff									●	●	○	●	○	○		●									
State Governors/State Energy Offices	●	○		○	○			○	●	●	●	○	○	○		●			○	●	●	●	○		
DOE Regional Offices	●	○		●	○			○	●	●	●	●	○			●			●	●	●	●	○		
State Legislators and Staff	○	○		○	○			○	○	●	○	○	○			●				●	●	●	○		
Congress and Staff					○				●	●		●	○	○		●									
Federal Building Agencies	○	○		○	○			●	●	●	●	●	○	○		●	○			●	●	●	●		
Industry Associated Executives	●	○		●	○	○			○	○	○	●	○	○		●				●	●	●	○		
Architectural Educators	○			●	●	○		●	○	○	○	○	○	○		●	○		○			●	●		●
Engineering Educators	○			●	●	○		●	○	○	○	○	○	○		●	○		○			●	●		○

○ Some Impact ● Greater Impact

Figure 3.1. Technology transfer mechanisms for specific audiences.
Source: Watts, et al. (1985)

Table 3.3 A Mechanism/Audience Matrix for ORNL's Buildings Equipment Research Program

Transfer Mechanism:	Audience Segments:		
	Consumers	Manufacturers	Utilities
Direct marketing	•		
Technical reports	•	•	
Workshops	•	•	
Subcontracts		•	
Cooperative R&D	•		
Personal communication		•	
Industry advisory committees		•	•

[a]o indicates that a mechanism is used to reach a particular audience segment.

Source: Revised from material developed by ORNL for a BCS program review.

costliness of workshops), and EPRI committees will be more appropriate than GRI committees to reach utilities (due to the different technology interests of each).

3.2 INSTITUTIONAL TECHNOLOGY TRANSFER RESOURCES AVAILABLE TO BCS

The technology transfer efforts of the Office of Buildings and Community Systems can be enhanced by capitalizing on DOE's generic technology transfer mechanisms and by coordinating with the activities of other federal technology transfer programs. These institutional resources are shown in Figure 3.2 and briefly described in Appendix A. These resources provide vehicles by which general, consumer, or technical information can be disseminated, such as the National Technical Information Service, Conservation and Renewable Energy Inquiry and Referral Service, and the Office of Research and Technology Application. Other resources provide incentives and other support for technology transfer, including programs which affect end use (e.g., the Weatherization Assistance Program), provide support for the invention and innovation process (e.g., the Energy-Related Inventions Program), or encourage cooperative R&D (e.g., the University/DOE Laboratory Cooperative Program).

3.3 DEVELOPMENT OF A TECHNOLOGY TRANSFER STRATEGY

We have described a number of transfer mechanisms and suggested the advantages and limitations of each and appropriate situations for using them. A technology transfer strategy is a combination of these mechanisms, tailored and combined to fit the R&D product, the audience segments, and the context in which the transfer is conducted.

A variety of questions need to be addressed in developing a strategy. Perhaps most important is "Who should be reached by what program, and what transfer mechanisms should be used?" The answer provided by ORNL's Building Equipment Research Program was presented as a mechanism/audience matrix in Table 3.3. Guidance on an appropriate match between audience and transfer mechanism can be obtained from Table 3.2 and from the results of needs assessments.

The exchange of information pertaining to R&D products and results is essential to technology transfer. By creating an awareness of a technology and its characteristics, as well as of alternatives, communication lays the basis for evaluation and, ultimately, a decision regarding adoption. Thus, there are several questions which relate to communication planning.

"What type of information should be communicated?" is a key question. The content of the message should reflect, at a minimum, the current knowledge of each audience segment and the criteria each employs in deciding to use or not to use the results of building energy R&D. Also to be considered is the role of competing messages and ways to handle problems associated with them. Informative, factual, and interesting messages are most effective overall. In preparing these messages, it is crucial to translate them into the language of the groups to whom a transfer activity is directed.

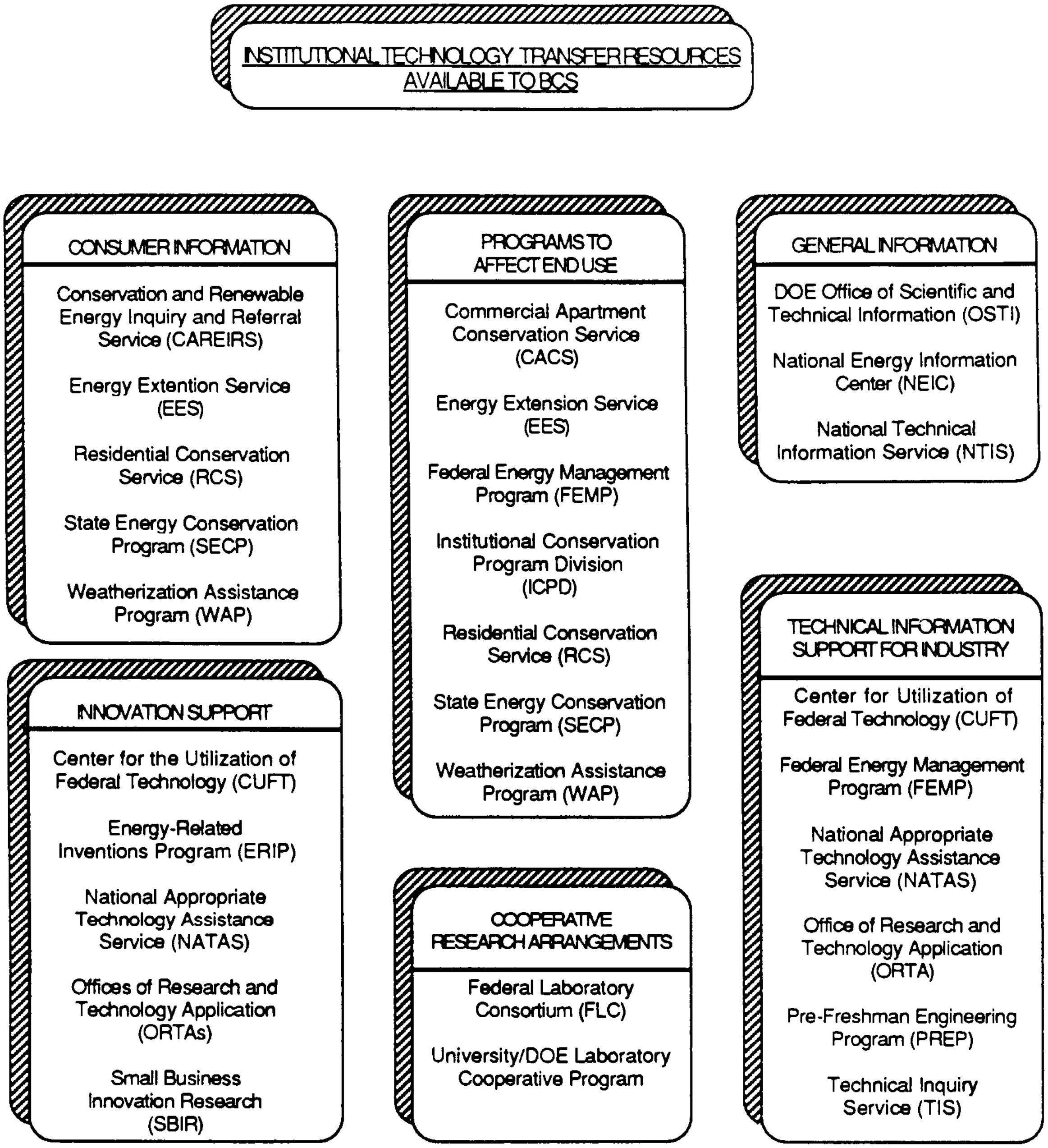

Figure 3.2 Institutional resources available to BCS's technology transfer efforts.

The most effective communications are positive and stress the benefits to be obtained through use of the R&D results. Negative approaches such as fear-arousing appeals may be appropriate in certain circumstances. Format decisions are based on the needs of the audiences as well as the requirements and limitations of the selected media and the type of message. For example, the target audience may need to be shown a product in use, or to have graphic illustrations. If substantial detail is necessary, the best format may be a journal article with tables, photographs, and detailed engineering drawings.

"Who should do the communicating?" Selection of the appropriate information source should reflect factors such as source credibility and persuasiveness. In general, energy communication studies have found that government-sponsored messages carry more credibility than appeals initiated by businesses which may appear to have a vested interest (Millstein, 1977). People tend to attach still greater credence to such sources as national laboratories, research institutions, and universities. Linking messages to these sources will generally improve effectiveness. In other instances, it may be most cost-effective to disseminate information through a trade or professional association because greater credence and attention are given to them and they have already established communication channels with their constituents. Key consumers are an alternative source of information. Through testimonials and other demonstrations, they may be able to persuasively document the virtues of using a technology to those who are resistant.

What types of incentives should be offered? In addition to providing information, establishing incentives or reducing barriers to adoption can be effective in stimulating use of an energy-saving technology. For example, the provision of grants or technical assistance to a small number of firms for conducting feasibility studies might be highly effective in creating some initial usage of the technology. Rebates and low-interest loans are alternative incentives. Unfortunately, little is known about the effectiveness of different types of incentives. The effect of size of an incentive and the possibility of threshold effects are open questions. It appears as though incentives affect mainly those energy users who are already paying attention to the costs of energy efficiency--that is, those who might have adopted an energy-saving technique or product without assistance. If this is so, incentives may increase the pace of adoption, but not the ultimate level of use. Even less is known about the impact of non-financial features of incentive programs such as program marketing, the time required to receive an incentive, and the red tape, record-keeping and other effort needed to take advantage of an incentive (Stern, Berry, and Hirst, 1985).

"When should different types of transfer activities take place?" The optimum mix of transfer mechanisms is in constant flux as new opportunities become available, audiences season and become educated, and technologies mature toward economic viability. Transfer strategies can sometimes capitalize on such dynamic factors as the readiness of various audience segments at different points in time and the effectiveness of different mechanisms during the various stages of technology development. In general, printed material seems to be particularly effective when a technology is first being introduced, especially where the offering is an idea requiring a detailed explanation (Rogers, 1983). Incentives may be particularly cost effective at the initial stage of commercialization to stimulate early adoption by trend-setting

3.4 BARRIERS TO EFFECTIVE TECHNOLOGY TRANSFER

Barriers to technology transfer of BCS R&D results have many sources and characteristics--in part because effective technology transfer for R&D results covers a wide spectrum of steps and processes. Following is a brief summary of technology transfer barriers that have been recognized by industry representatives and researchers. They have been grouped into six categories for discussion purposes: programmatic barriers, legal constraints and barriers, institutional barriers, building industry characteristics, information transfer barriers, and market barriers.

3.4.1 Programmatic Barriers

The lack of an institutionalized coordination process between the public and private sectors in the definition of research needs and objectives, program planning and evaluation has been cited as a significant hindrance to successful technology transfer in the buildings industry (Science Applications, Inc., 1983). In general, there is little planning for the transfer and utilization of anticipated research results to specific target audiences. This is compounded by the fact that DOE allocates only a small fraction of its budget to technology transfer activities (Brown, et al., 1985), and there is a lack of understanding and utilization of existing transfer mechanisms for various building sectors. The Technology Transfer Roundtable concluded that, in particular, "proof of concept" demonstrations in actual buildings have been too infrequent given the key role they can play as a linkage between initial laboratory results and acceptance and use (ASHRAE, 1985).

3.4.2 Legal Constraints and Barriers

Design and product liability requirements can prohibit adoption of new products because of a lack of product validation procedures and facilities (Science Applications, Inc., 1983). Codes and standards covering building materials and equipment have limited effectiveness for several reasons: (1) codes are often mostly concerned with safety and reliability rather than energy efficiency and (2) industry consensus standards have long time requirements for adoption (Achenbach, 1982). Federal income tax depreciation allowances encourage sub-standard building construction and discourages investment in energy conservation renovations. Building construction and short-term ownership is often motivated by acquiring income tax write-offs against business income rather than long-term or life-cycle economics (Science Applications, Inc. 1093). Finally, the DOE patent policy has been a significant barrier to cooperative R&D and technology transfer to private industry. By retaining patent titles and granting non-exclusive licenses for federally-sponsored inventions, the federal government does not allow private companies to protect their investment in product development from the risk of competitors (Soderstrom and Winchell, 1985).

3.4.3 Institutional Barriers

Much commercial office space is leased under agreements that do not allow pass-through of investment costs or savings from energy-efficient equipment replacement or building modifications (U.S. Congress, 1982). Master metering of apartment buildings and other multi-occupancy structures leads to this important barrier in much of the U.S. building stock.

There are also institutional barriers related to the multifarious roles played by the numerous different parties involved in building design and construction. For instance, the design of many large buildings involves an architect for the building envelope design and mechanical engineers for the HVAC system design. If the overall design is not coordinated between the building envelope and HVAC system designers, the selection and sizing of HVAC equipment can be made on a sub-optimal basis relative to minimum life-cycle costs. This situation can result because the ultimate decision may be made by the architect rather than the mechanical engineer on the basis of minimizing the first cost of equipment to stay within a construction budget.

3.4.4 Building Industry Characteristics

The building industry is fragmented into a large number of small- and medium-sized firms involved in a wide variety of activities (Achenbach, 1982; Brown, et al., 1985). It also includes a wide diversity of building types--residential, commercial, industrial, and institutional--which function as separate industries with little communication or technology transfer among them (The Business Roundtable, 1982). This fragmentation inhibits the flow of information within the industry and the ability to conduct cooperative R&D.

3.4.5 Information Transfer Barriers

The volume of technical information being published in the many areas of building technology is so large that potential users are overwhelmed by the task of evaluating it. Current bibliographies of technical reports on building technology typically cover a limited subject matter, their distribution is limited, and few, if any, have been computerized for rapid access. There is no central clearinghouse for technical information on building technology (ASHRAE, 1985).

In particular, there is poor communication between the various public and private sectors on research being performed. Technical information from research laboratories is presented in formats that are not readily usable by designers, manufacturers, trade associations, builders, and owners. Technical handbooks are generally seen to be an effective medium for communicating research results, yet the integration of DOE R&D results into these publications is not being done on a systematic or frequent basis (ASHRAE, 1985).

At the same time, inaccurate perceptions and a lack of credible and appropriately formated information is a problem within many sectors of the building industry. The impression of consumers that all of the "easy" or most cost-effective energy savings measures have been implemented must be counteracted by DOE initiatives that demonstrate reliable and cost-effective energy-saving techniques to the various building market segments (ASHRAE, 1985). Uncertainties exist concerning paybacks to implemention of new energy-efficient investments which have been enlarged by a record of great variation between the predicted and actual performance of equipment and materials. There are also uncertainties about future energy prices. These unknowns increase the perceived risk to end-users and financial institutions when considering the financing of new technologies and products for buildings (Science Applications, Inc., 1983). Owners of small commercial buildings and other key decision-makers also lack access to credible information on energy efficient technologies.

3.4.6 Market Barriers

The high perceived risk of energy-efficient investments is a barrier for many building owners. Only very short payback investments (<2 years) are often considered or used by owners of commercial buildings (Science Applications, Inc., 1983). This is partly because of the imperfect ability of the housing and commercial building market to capitalize fuel savings into market values. Energy costs in many buildings are a relatively small part of the total cost of space or of operating a business. Hence, cost savings from energy-efficient investments have a low priority compared with measures to improve worker productivity and other alternative investments. The current perception that energy costs will not escalate rapidly in the future, as was the case in 1973-82, has reduced the motivation for energy-efficient investments for future cost savings (ASHRAE, 1985).

3.5 EVALUATION ACTIVITIES

Evaluation activities are an integral part of the process of developing and refining a technology transfer strategy. They allow the program to capitalize on lessons learned from past technology transfer activities and to systematically determine whether objectives are being realized.

Evaluations of technology transfer activities are subject to many conceptual and methodological problems. For instance, it is frequently difficult to differentiate between the technology or information about it and the process of delivery (DeLeon, 1984). It may also be difficult to distinguish between the beneficial program outcomes from unintended ones (Gibbons, 1984). Such issues have at least partial solutions through the choice of evaluation design (Dunn et al., 1984), and the extent to which the design can eliminate potential rival hypotheses (Cook and Campbell, 1979). At a more practical level, the establishment of evaluation criteria when a technology transfer strategy is first implemented will increase the probability of detecting program effects (DeLeon, 1982).

No single evaluation approach is suitable to analyzing all technology transfer activities, nor do all activities need a formal evaluation to assess their impact. The short- and long-term goals of different technology transfer activities dictate, to some extent, the evaluation strategy and the evaluative criteria (e.g., energy savings, user satisfaction, market penetration, program implementation, cost effectiveness, or attitude change) to be used.

While many BCS technology transfer activities are informally evaluated, formal evaluations are seldom conducted. One example of a formal assessment is the recent evaluation of the Institute on Energy and Engineering Education (Brown and Hite, 1985). Information from participants was gathered to determine the effectiveness of the five Institutes on Energy and Engineering Education held between 1980 and 1984. Two types of data were collected: the first dataset was generated through questionnaires completed during the last day of each Institute, and the second dataset was developed from follow-up telephone discussions with a sample of 54 participants from the 1980 through 1983 Institutes. Effectiveness was assessed in terms of participant satisfaction, curriculum changes, follow-on interactions between participants and DOE, and subsequent networking between participants. The overall conclusion was that the Institute has served it mission well, and that by evolving in response to changes in the engineering professions and to energy technologies, it will continue to do so. Specific recommendations were made, many of which were implemented in the 1985 Institute.

Needs assessments and evaluation activities can be seen as the first and last stages of a cycle of four sets of activities, each occuring on a periodic or recurring bases. The cycle is comprised of activities to:

- assess needs
- develop transferable information
- conduct outreach activities
- evaluate progress and gather feedback.

The assessment of needs determines the technology transfer strategy, which in turn is comprised of information development and outreach activities. After implementation, these activities are evaluated through various feedback and other activities to determine their effectiveness and improve the cost effectiveness of future activities.

3.6 FIVE PROTOTYPE STRATEGIES

Five technology transfer strategies are discussed in detail in Chapters 4 through 8. They represent different overall appproaches to a transfer problem, each with its own characteristic set of transfer activities, its assortment of advantages and disadvantages, and its appropriate situations for use. The five strategies are designed to:

- target key decision-makers
- engage in laboratory/industry cooperative R&D
- focus on innovators and leaders as industrial partners
- work through trade and professional associations
- generate end-user demand

While there are many more possible strategies, these five appear to be especially pertinent to BCS and are discussed in the following chapter. Table 3.4 offers an overview of the characteristic advantages, disadvantages, and situations for appropriate use of each of the five prototype strategies.

	TARGETING KEY DECISION-MAKERS	LABORATORY/INDUSTRY COOPERATIVE R&D
ADVANTAGES	•identifies specific audiences by decision-making activities •provides logic for designing specific marketing approaches •can achieve higher impact than broad-casting untailored information	•disseminates information quickly to industry •generates industry focus on market needs leading to more transferable technologies •gains access to enhanced resources through sharing of equipment, funds and expertise
DISADVANTAGES	•risks of over-generalizing expected results until tested •expensive to conduct necessary background research and follow-up evaluation •expensive to implement	•may require special organizational units to be established which may be expensive to coordinate •proprietary interests of participating companies may dis-courage the sharing of information •the nonproprietary dissemination of infor-mation may discourage product development
APPROPRIATE SITUATIONS	•at later stages of R&D when a product or result is available or during early stages of industry acceptance •when R&D findings are technically intri-cate or difficult to observe or commun-icate •when R&D findings need to be targetted for use by diverse audience segments	•at initial stages of R&D before product applica-tions are established •when R&D is not product oriented •when R&D has broad applications affecting two or more industries •when the ultimate mar-ket is large enough to involve many firms •when companies in the industry are cash poor and need to join together to support R&D

Table 3.4. Technology transfer strategies: characteristic advantages, disadvantages and appropriate situations for use.

INNOVATORS AND LEADERS AS INDUSTRIAL PARTNERS	TRADE AND PROFESSIONAL ORGANIZATIONS	GENERATING END-USER DEMAND
•overcomes "not invented here" syndrome •allows companies to keep proprietary information •carries technically feasible inventions into commercial production •potentially reduces costs •gains access to enhanced resources through the sharing of equipment, funds and expertise	•strategy supported by the building industry •may provide a channel for assessing the needs of the industry •may provide a channel for sharing BCS R&D results equitably and efficiently •can be inexpensive •gains access to enhanced resources through sharing of equipment, funds and expertise	•consumer education can achieve long-term behavioral change •some consumer education activities are low cost
•may be difficult to choose a partner •risk and equitability problems associated with reliance on a single firm or partner	•possibly limited organization membership •"vested interests" of the organization may distort or limit information transfer •potential for breakdown of communication between the organization and its constituents •loss of control over information transfer	•direct market interference can create unintended distortions •some consumer education activities are ineffective •wide variability in effectiveness
•product oriented R&D •reliance on "diffusion effects" via opinion leaders is most effective when benefits are visible, easily documented,	•when a credible and reliable communication network already exists within the industry's associations •at all stages of the R&D process, but particularly for long-range, utilization, application and impacts research •when limited resources are available for technology transfer	•when rapid changes in consumer behavior are required •when products aimed at the consumer are technically difficult to understand •when actual energy savings are difficult to observe •when R&D pertains to utilization, application or impacts

Table 3.4. Technology transfer strategies: characteristic advantages, disadvantages and appropriate situations for use.

4. TARGETING INFORMATION AND INCENTIVES TO KEY DECISION MAKERS

4.1 INTRODUCTION

The goal of this strategy is to increase the application and adoption of R&D results on energy efficient technologies by carefully identifying key industry and building owner, operation, and maintenance decision makers, then targeting information and incentives to selected market segments that include these decision makers. The information and incentives must be designed to meet the decision needs of individuals in these industry segments.

A variety of approaches can be taken to identify decision makers and decision criteria for specific energy conservation opportunities. Sometimes the decision makers are few in number and well known. For instance, building retrofit typically involves only the owner and a contractor. In other cases, the decision-making process is more complex and requires careful analysis to determine the individual making specific types of decisions. For example, construction of a new shopping mall involves the building owner, architect, contractors, mechanical, electrical and civil designers, financiers, plus others.

Targeting information and incentives for key decision makers has the potential advantage of a higher response rate relative to an untargeted strategy. However, the targeted strategy requires the selection, implementation and evaluation of appropriate information and incentives which may need to be specific to each audience segment and R&D product. Therefore, the "targeting" strategy requires much more analysing and understanding of the R&D product, the decision processes and criteria of various market segments, and the interactions between them than is required for an "untargeted" strategy.

This section begins with a brief discussion of the development sequence for the strategy and the strategy's advantages and disadvantages. Then a more detailed description is presented for a relatively new targeting procedure - the Pacific Northwest Laboratories (PNL) Decision Process Model - that was developed for the BCS Research Utilization Program. Finally, conclusions are presented in terms of appropriate situations for application of the targeted transfer strategy.

4.2 DEVELOPMENT SEQUENCE

The development sequence for these strategies involves the following steps:

1. Identify a technology or research product.
2. Specify the applications of the technology in terms of the building or equipment types.
3. Define the target audiences for each technology application.
4. Select the most cost effective transfer mechanisms.
5. Execute the transfer mechanisms.
6. Evaluate effectiveness of the transfer activities and adjust steps 1-5, as needed.

There are many ways of completing steps 3 and 4, including: review of the literature and past experiences, use of delphi approaches including advice from industry review panels, completion of needs assessments and market studies, use of decision theory and social network analysis, and application of the Pacific Northwest Laboratories' (PNL) Decision Process Model.

4.3 ADVANTAGES AND DISADVANTAGES

As was noted earlier, the targeted information dissemination strategy can result in higher response rates than untargeted strategies because transfer mechanisms can be tailored to the specific needs of key decision making market segments. If a targeted strategy includes the identification of decision criteria used by key decision makers, then the selection of transfer mechanism can also include consideration of important motivations for specific subgroups and further improve the response rate.

The increased effectiveness of targeted versus untargeted strategies is countered by the relatively higher cost of implementing targeted information and incentive strategies. This disadvantage must be considered in terms of the broader context. For example, the higher cost disadvantage applies particularly when budget limitations restrict the financial resources available to support such a strategy. In other situations the increased effectiveness can be seen to more than compensate for the higher cost.

4.4 DECISION PROCESS MODEL OF THE PACIFIC NORTHWEST LABORATORIES

The PNL decision process model (Watts et al., 1985) is a model designed specifically for application to the construction of new buildings, although it could also be applied to large building renovation projects. It identifies 24 discrete decisions which have implications for the ultimate energy efficiency of a buildings. These decisions are seen as occurring during six stages: pre-design, schematic design, design development, bid process, building construction, and occupancy. The idea is to determine which of 25 decision participants (e.g., developer, general contractor, or inspector) dominates each decision, and which of 21 decision criteria (e.g., intitial costs, lease potential, or aesthetics) affects each decision.

The pattern of decision makers and decision criteria are assumed to vary as four key parameters change:

- ownership type
- ownership mode
- building type
- contract mode.

Therefore the model must be applied across a range of situations to achieve a comprehensive data base. Tables 4.1 through 4.4 show the possible combinations of each of these parameters. Table 4.5 shows the types of decision participants identified in the model and Table 4.6 shows the criteria specified by the model. Table 3.2 presents a range of transfer mechanisms that might be employed to stimulate technology utilization.

4.4.1 Example - New Small Office Building

A preliminary application of the decision process model has been completed by PNL. This application covers one specific combination of parameters that drive the decision process:

- Ownership type: Owner-occupant; small business
- Ownership mode: Owner/resident
- Building type: Small office building
- Contract mode: Design-bid-build

The results of this application, presented in Figure 4.1, were obtained by telephone interviews and written correspondence with the various types of decision participants identified in the figure. Figure 4.1 shows the level of decision involvement for each decision participant for a range of energy conservation opportunities throughout the developmental phases of a building. In Figure 4.2 the level of importance of the various decision criteria are presented for the same range of energy conservation opportunities. The initiator and major decision level participants in Figure 4.1 use the most important decision criteria in Figure 4.2 for decisions about energy conserving technologies. These criteria are dominant motivating factors controlling technology adoption.

Figure 4.1 shows the case of the small office building, with an owner occupant. The building owner dominates the design phases of the project as the initiator, with the architect/engineer the next important decision participant. Thus, the important characteristics of the building envelope, which will control energy losses and gains through the building's "skin," illumination level and lighting efficiency, and ultimately the building's heating, cooling, and ventilation energy use, are predominately determined by the owner and architect/engineer. The decision criteria for these design phase decisions place less than major importance on the life cycle cost criteria, as compared with the initial cost criteria. This situation indicates that building energy efficiency decisions may be subverted with respect to decisions that minimize initial cost.

Another key decision participant involved in energy decisions during the design stage is the mechanical engineer (Fig. 4.2). The decisions for which the mechanical engineer is the initiator all have major importance assigned to the life cycle cost criteria, indicating that energy efficiency considerations can play an important role through the influence of the mechanical engineer.

The general contractor assumes the dominant role of initiator during the building construction phase of the project. The contractor's primary role is to implement the design decisions made by others. In fulfilling this responsibility the contractor can negate an energy-

Table 4.1 Building ownership types

For-Profit: Owner-Occupant	For-Profit: Invester-Owner
Individual	Individual
Small business	Development company
Large corporation	Local Partnership
	National partnership
	Institutions--insurance, pension funds

Nonprofit

- Individuals
- Institutions--government, educational, hospitals
- Private organization--religious, social, union

Table 4.2 Building ownership mode

Owner/resident	Owner/nonresident
Expects to occupy the structure after completed.	1. Expects to lease the building; tenant likely be responsible for operating, maintenance and utility cost 2. Owner expects to lease building space but will be responsible for operating, maintenance and part or all utilities.
Corporate/franchise ownership	**Developer/speculator**
Expects to occupy the premises but design and investment decisions frequently are made at corporate levels far from the building location.	Expects to sell the structure to future landlords or occupant/owners.

Table 4.3 Building types

Residential-single family	
Single family attached	
Single family detached	
Mobile homes	
Commercial (NBEC) classification	
Assembly	Office
Auto sales & service	Retail/services
Education	Residential--multifamily, apartments, condominiums
Food sales	Warehouse/storage
Health care	Other
Lodging	

Table 4.4 Construction contract modes

Design-bid-build	Design-build
Design activities set forth, a bid process follows; building constructed by the successful bidder.	Increasingly common; eliminates a separate bid process. Owner usually further removed from key energy decisions because contract includes both design and construction tasks.
Negotiated construction contract	Fast-track and multiple-bid package jobs
Can have same design activities but differs greatly in construction phase. Various segments of construction let to individual contractors on basis of experience and reputation without accepting and reviewing multiple bids.	Several complexities and variations; possible pre-engineered, pre-cut or pre-fabricated; some cases mechanicals are installed and even designed after shell past is in place. Can be constructed with all systems and all appliances integrated.

Table 4.5 Decision participants

Owners/Financiers	Manufacturers/Suppliers
- Owner/property manager	- Manufacturer/processor
- Developer	- Distributor/dealer
- Real estate broker	
- Lending institution	
Designers/Specifiers	**Contractors**
- Architect	- General contractor
- Mechanical engineer	- Construction/project manager
- Structural engineer	- Electrical contractor
- Electrical engineer	- HVAC contractor
- Energy engineer	- Plumbing contractor
- Illumination consultant	- Roofing contractor
	- Conveyance contractor
	- Specialty contractor
Regulators	**Building users**
- Zoning officials	- Occupant/lessee
- Inspectors of all levels: local, state, and federal	- Energy manager
	- Maintenance manager

Table 4.6 Decision criteria

Economic	Functional
- Initial cost	- Ease of installation
- Payback/return on investment	- Ease of maintenance
- Life cycle cost	- Ease of operation
- Operating cost	- Durability/reliability
- Sale/resale potential	- Flexibility
- Lease potential	- Safety/health
	- Modularity: maintenance/expansion
	- Systems compatibility
Regional	**Individual**
- Climatic/geographic factors	- Preference
- Compliance (codes/standards)	- Professional reputation
- Style/trend	- Aesthetics
- Availability	

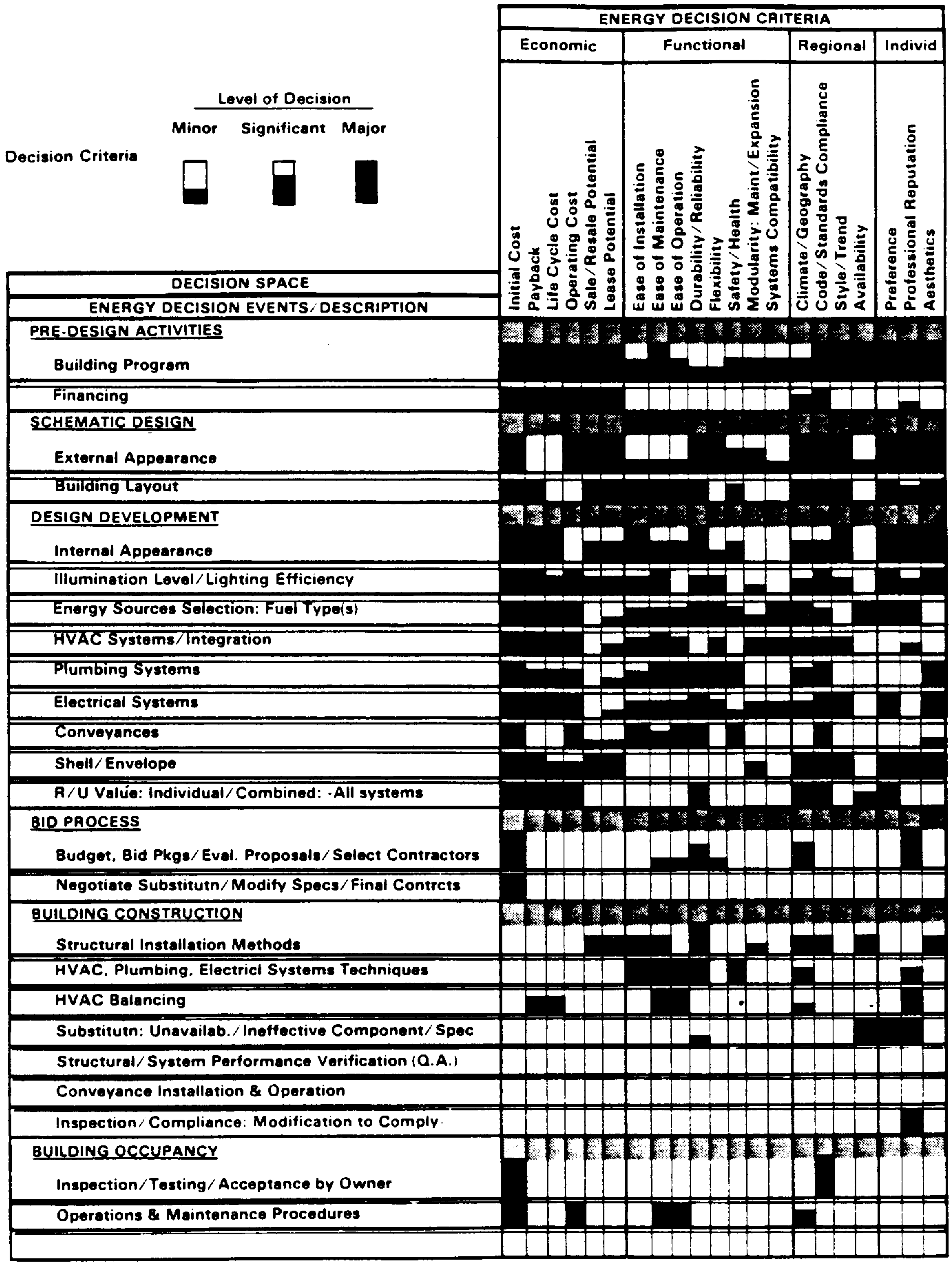

Figure 4.1. Level of involvement of various participants in energy decisions. Source: Watts, et al. (1985)

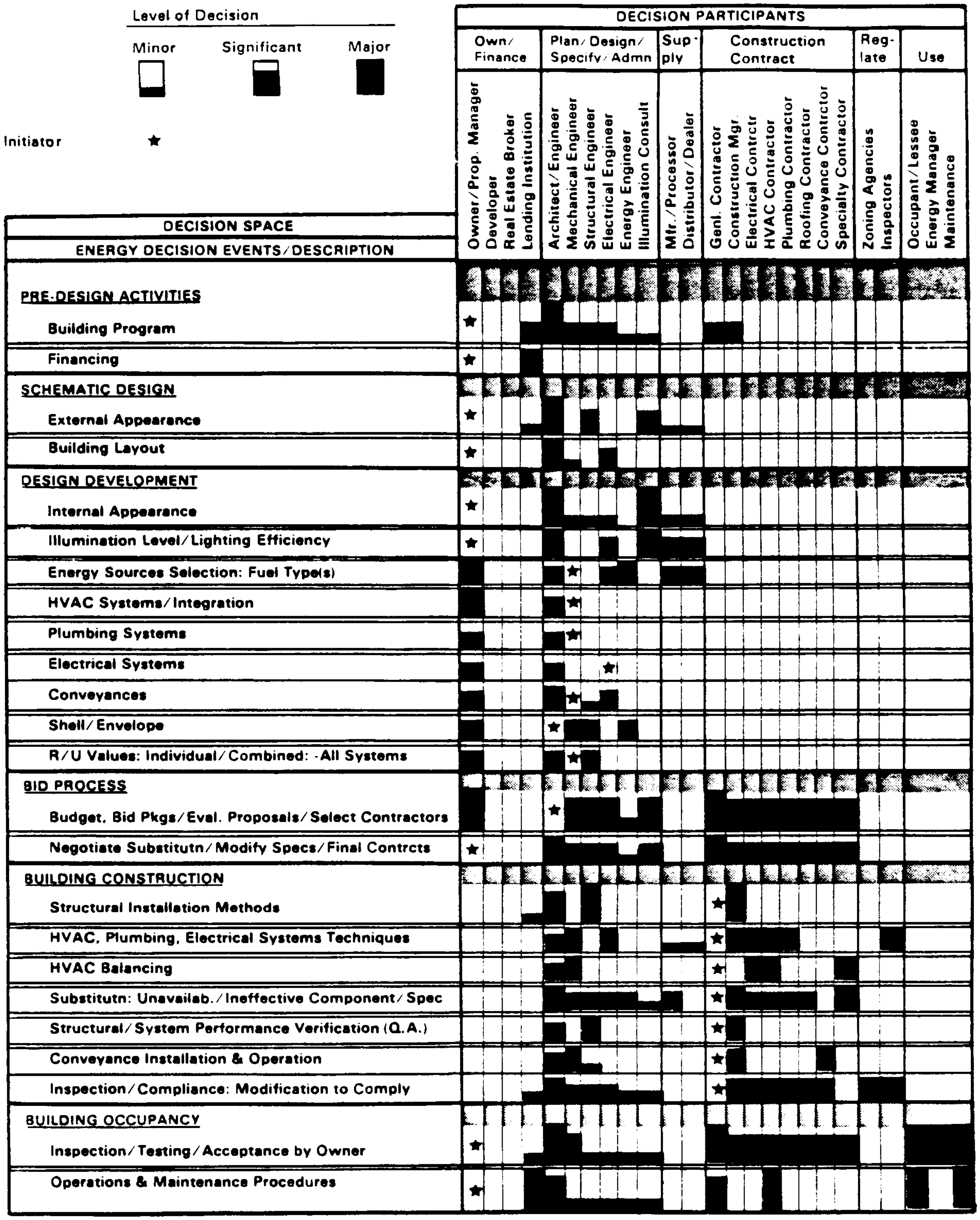

Figure 4.2. Level of importance of various criteria in energy decisions. Source: Watts, et al. (1985)

efficient design decision by improper installation or could influence final equipment selection positively or negatively. The important decision criteria affecting this phase are primarily functional in nature and include ease of installation, operation and maintenance, durability, reliability, safety, and health.

The Decision Process Model is a particular strategy for identifying decision makers and providing insight into the kind of information and incentives that are most important in decisions regarding technology adoption. This strategy can be used along with user segmentation to define target audiences for information exchange for complex decision-making situations such as construction of new commercial buildings.

In summary, the key decision participants identified in the PNL analysis of this new commercial office building project are the owner, architect/engineer, mechanical engineer, and the general contractor. Specific technology transfer mechanisms appropriate for these decision participants were identified in the PNL study, and presented in Fig. 3.1.

4.5 APPROPRIATE SITUATIONS FOR THIS STRATEGY

This strategy of targeting R&D information to key decision makers appears to be used extensively within BCS programs, but in an ad hoc or intuitive fashion. Often, insufficient evaluation and feedback is performed to ensure that the targeting and formatting of information and incentives is justified and effective. As a conclusion to this discussion of the targeted transfer strategy, three characteristic situations are described for which this strategy is appropriate.

4.5.1 Timing

The first appropriate situation has to do with timing within the overall R&D process involving research, development, and commercialization. The targeted transfer strategy is most appropriately timed for later stages of research and development and the early stages of commercialization and acceptance. The rationale for this approach is that transfer mechanisms can be focussed on key decision makers and thereby influence individuals who may become "early adopters" of the specific R&D product. Thus the timing of this strategy is designed to initiate industry acceptance and promote the commercialization process.

4.5.2 Communicate Technically Difficult R&D Results

A targeted transfer strategy is appropriate when R&D results are technically intricate and difficult to communicate to a broad audience. In such a situation, the targeted strategy is uniquely capable because it tailors information to address the needs and motives of specific market segments that have been identified by the development sequence described in section 4.2.

An example of this strategy application is the Heat Pump Modelling Workshop conducted by ORNL Energy Division staff on August 31 - September 2, 1982. The purpose of this workshop was to present and demonstrate advanced computer modelling developments of the BCS-sponsored ORNL Heat Pump Research Program. The workshop attendees were private company research personnel and university engineering researchers involved in advanced heat pump development. The technically intricate R&D results and highly specialized audience was well suited to the targeted information transfer mechanism of a focussed workshop.

4.5.3 Diverse Audience Segments

The final appropriate situation for a targeted transfer strategy is when R&D results need to be targeted for diverse audience segments - that is, when the motivations and needs of key decision-making audiences are significantly different so that a single mechanism would be inappropriate and relatively ineffective. An example of this situation is the construction of a new small office building with the building owner being the resident business owner, described in section 4.5.1. The PNL Decision Process Model determined that the resident business owner and the building architect were the key decision-makers in energy conservation relative to technology choices for building design and construction. The business owners and the architect represent diverse audience segments with respect to their personal and professional decision-making criteria, and therefore should have individual mechanisms selected and applied to them.

There are many possibilities for diverse audience segments to exist for various building R&D products. However, some important causes for diverse audience segments are the different motivation of decision-makers in the consumers, manufacturing industry, and architect/engineering market segments, as discussed in section 1.3.

5. LABORATORY/INDUSTRY COOPERATIVE RESEARCH AND DEVELOPMENT

5.1 RATIONALE FOR LABORATORY/INDUSTRY COOPERATIVE R&D STRATEGY

This strategy involves laboratory scientists working closely with groups of firms throughout the innovation process in order to encourage communication between the researchers critical to developing the innovation and the business and marketing people whose skills are so necessary during commercialization.

In many circumstances, such a cooperative R&D strategy is an effective means of transferring publicly supported technological developments to the private sector. To complete the innovation process requires a variety of technical, marketing, financial, and business management skills and resources. Technologies created in federal laboratories are often developed by a team of scientists and engineers only to the point where technical feasibility can be demonstrated. Transforming government-sponsored inventions into commercial products of substantial value requires further nurturing of the idea and substantial investments of capital. Only about 10% of the final cost of new product development is involved in the research leading to the basic invention and advanced development. The other 90% is expended in engineering design, production engineering, tooling-up, manufacturing start-up expenses, and marketing start-up costs (Charpie et al., 1967).

To move a technology effectively through the entire process requires that the scientists and engineers developing the innovation be able to directly communicate with the business and marketing people attempting to commercialize it (Roberts, 1979). While a combination of these skills and resources is necessary throughout the innovation process, their importance varies at different stages in the process. As can be seen in Fig. 5.1, all the skills must be available at the right time for the technology to pass successfully through the entire process. (Shaded boxes in Fig. 5.1 highlight the skills and resources that are the most critical at each stage of the innovation process.) In general, the scientists are important to begin with, but business people become more critical as the technology moves closer to the marketplace. For example, at the research stage, creativity is the essential element; at the development stage, technical expertise and entrepreneurial skills are primary; and at the commercialization stage, business and marketing skills are most important.

Laboratory/industry cooperative R&D arrangements provide the opportunity for assembling the proper mix of skills while at the same time providing an organizational mechanism for structuring interactions and information exchanges between the original technology developers and industrial representatives seeking to adapt the technology for commercial applications. This synergism can help lead to a smoother progression through the entire innovation process.

Just as the relative importance shifts from technical to business skills as development progresses, roles, relationships, and relative levels of involvement between laboratory and industrial personnel change (Fig. 5.2). Typically, laboratory personnel are most heavily

STAGES OF THE INNOVATION PROCESS

RESOURCE	Research Idea/Invention	Product Development Evaluation/Adaptation Demonstration	Commercialization Product/Distribution
Technical	Scientific Creativity	Engineering Expertise	Manufacturing Expertise
Market	Market Information	Market Evaluation	Marketing Expertise
Financing	Research Funding	Development Financing	Operational Financing
Management	Research Planning	Business Planning	Business Expertise

Figure 5.1. Resources needed for innovation planning.
Source: U.S. Department of Commerce (1984).

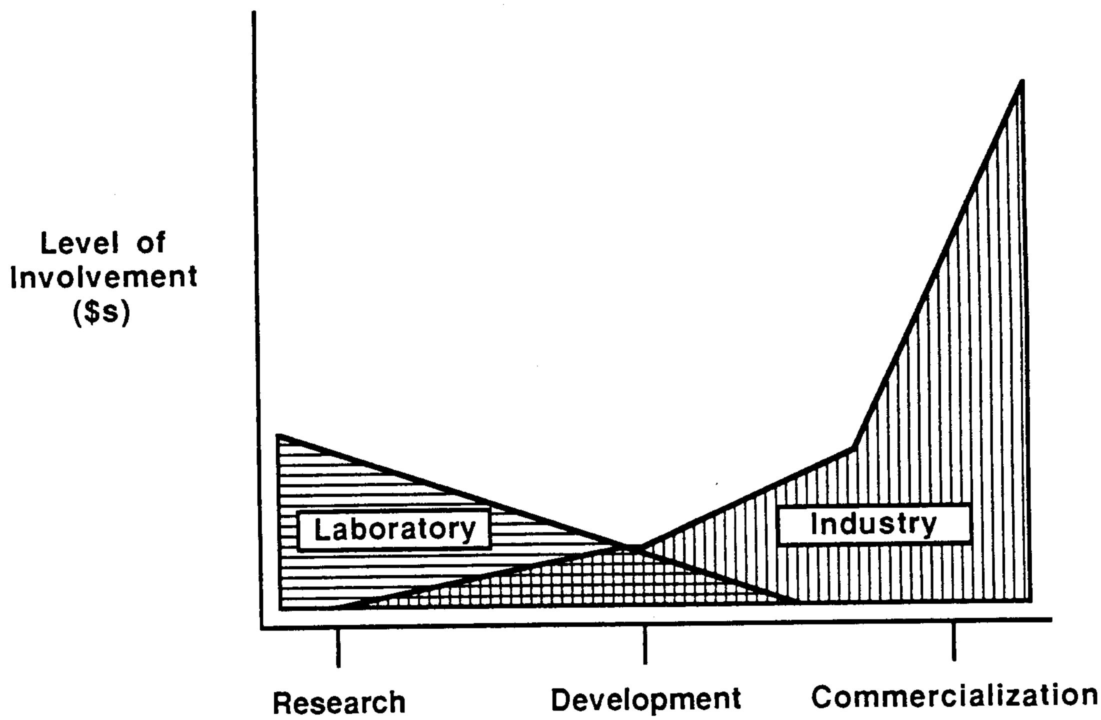

Fig. 5.2. Shift in level of involvement in completing the innovation process.
Source: Soderstrom, et al. (1985)

involved in basic research with the level of involvement decreasing as technologies progress into applied research and product development. Industrial personnel, on the other hand, are less involved in basic research. Their heaviest involvement comes in developing product applications and commercializing the technology. The nature and extent of industry involvement depends on the technical and business risks inherent in the further development and the commercial potential of the technology. The cross-hatched area in Figure 5.2 represents the development stages where common interests are highest. These stages also represent the greatest opportunity for developing cooperative relationships.

Despite the fact that industry involvement in the initial stages of public R&D projects tends to be minimal, cooperative R&D is most successful when it is initiated early in the R&D process. Experience argues for clear identification of users, user needs, and user reactions to types of technological solutions before the technological problem-solving occurs. "Technology push" must be balanced by "market pull," since successful commercialization depends at least as much on market needs as on technological opportunities (Myers and Marquis, 1969; Myers and Sweezy, 1978). As Robbins (1984) suggests, the real problem for government technology transfer programs is how to develop technologies that are transferable. By involving industry in early stages of the R&D process, market needs are given a stronger role.

In addition to stimulating technology transfer, there are other benefits from cooperative R&D. Interactions with industry may lead to the initiation of new research projects for new sponsors, generating funding support in areas of interest to BCS. Existing activities, facilities, and equipment may be maintained or expanded through the generation of funds from industrial use. Finally, cooperative arrangements may lead to improvements in the quality of BCS-supported research. For instance, researcher exchanges offer opportunities for scientists to work on different types of problems with different equipment, facilities, and colleagues.

5.2 TYPES OF COOPERATIVE R&D AGREEMENTS

Some cooperative research requires that a special type of organizational unit be set up to handle such activities. Others can be negotiated at the level of the individual researcher or through existing groups, and may be relatively informal. Various types of cooperative R&D agreements are described below and illustrated by examples of their use in BCS programs.

5.2.1 Advisory Boards and Review Panels

Many BCS programs have institutionalized industrial cooperation through the creation of advisory boards and review panels. These groups typically are composed of representatives from industry, universities, and public-sector organizations who convene periodically throughout a program of research. They help to define R&D needs, identify capabilities for joint endeavors, provide periodic critiques of programs, and may become personally involved in technologies of interest to their organizations. In most cases, panel members do not have, nor expect, contracts from the programs they advise.

The review panel for BCS's thermal mass program is a case in point. Organizations which have participated in this review panel include:

- Bickle, CRS Group, Inc.
- Brick Institute of America
- Forest Products Association
- Log Home Council/Steven Winter Association
- Members and Assoc., Architects
- National Association of Home Builders (NAHB)
- National Concrete Masonry Association
- New Mexico Energy Institute
- Owens Corning Fiberglas Corporation
- Portland Cement Association
- University of Pittsburgh
- EPRI

The Electric Power Research Institute (EPRI) has been a joint sponsor of the review panel. Another example is the LBL Building Energy Analysis Group's industry review panels which have been variously comprised of the International Masonry Institute, Log Homes Council, NAHB, National Concrete Masonry Association, and regional builders.

Rather than establishing a standing committee which is convened periodically throughout an R&D program, review meetings with industry, university, and other interested parties may be organized on a one-time-only basis. For instance, in FY 1984 ORNL held a joint planning meeting on nonazeotropic refrigerant mixture research with EPRI, NBS, Dupont, and Allied Chemical Company. Similarly, NBS held a workshop with private sector participants to identify research needs in the area of thermal anomalies, thermal bridges, and thermal breaks.

Instead of providing advise on an entire R&D program, a group may be formed to review the progress of a particular project. For instance, concurrent with a supermarket refrigeration project, ORNL formed a project advisory group of operating engineers from supermarket chains and held periodic reviews with the Food Marketing Institute.

The Building Energy Analysis Group at Lawrence Berkeley Laboratory (LBL) has developed a strategy of industry review and advise which takes on different forms at different stages in the completion of an R&D effort. Industry advise on the development of workplans is sought informally, industry review panels are convened upon completion of interim milestones, and industry and public review occurs when preliminary final results are available. This system has the advantage of allowing different industry groups to participate in an R&D program at different stages, thereby widening the possible arena of responses. On the other hand, it does not provide the more dedicated involvement that comes from industry membership on a more permanent and ongoing advisory board.

5.2.2 Cooperative Research Consortia

Corporate funding of BCS-supported research projects on the part of multiple firms (i.e., a cooperative research consortium or center), typically involve formal agreements through which participants contribute specific resources and are assigned pre-defined patent and publication rights. These arrangements allow organizations to pool their resources to support research of shared interest (Office of Technology Assessment, 1984).

In a typical cooperative research consortium arrangement, each company would contribute only a portion of the cost of the research, but would receive information on all the work conducted. The center may retain patent rights on any new technologies, with member companies usually receiving nonexclusive, royalty free licenses. Nonparticipating firms may also be licensed, and royalties from them are shared based on annual firm contributions (Johnson and Tornatzky, 1981). Known as leveraging, this pooling of small investment justifies high-risk research by minimizing the cost to each member. It also reduces R&D duplication because companies share information on common problems.

Projects that are not product-related fit particularly well into this cooperative mode. Research on the marginal or negative properties of building materials are examples and include such issues as fire safety, corrosion, aging, shrinkage, settling, and toxic emissions. Research of this nature needs the attention of the private sector but would probably not be conducted, or at least published, without public support or a consortium arrangement.

One example of a cooperative research consortium was established to test the moisture performance of plastic type sheathing. Jim Walter Research Corporation asked the Forest Products Laboratory (FPL) to consider a project to do a field test comparing the generic plastic product with hardboard sheathing. After considering the proposal, it was decided to expand the project to involve others interested in a design guideline for moisture control through walls. Dow Chemicals, the Insulation Board Association, the U.S. Department of Housing and Urban Development, and the National Forest Products Association joined in supporting the research. The Forest Products Laboratory constructed a test building and conducted the research; the consortium monitored these activities and had access to the research findings (Bales, 1985).

5.2.3 R&D Limited Partnerships

Research and development limited parterships (RDLP) are a special form of cooperative R&D arrangement. The RDLP is a type of business organization which makes it possible to form syndicates to raise capital for R&D. Although there may be infinite variations, the typical RDLP structure includes the three following major components:

- a technology that can be researched and/or developed to provide a return in the commercial marketplace,

- significant equity capital contributed by limited partner investors to finance the development, and

- royalties on product sales (resulting from R&D) that flow to limited partners in the form of capital gains.

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

Figure 5.3 shows how an RDLP might be structured for a DOE laboratory around a nationally recognized institute or center of excellence. In this arrangement, the laboratory provides the partnership with a license to the basic technology. In return, the partnership would contract with the laboratory for further development of the technology. Upon successful completion of the R&D, the partnership would gain ownership of the new development. The rights to the property could then be licensed to a manufacturer for the marketing of the product. Royalties would flow back to the partnership from this commercialization effort.

Research and development limited partnerships offer a potential source of development funds in the following instances:

- to develop worthwhile technology that, because of its size or complexity, requires joint venture funding;

- to allow broad participation, financially or technologically for BCS technology; and

- to allow medium and small firms an opportunity to develop projects that would normally be beyond their individual resources.

As one example, Los Alamos National Laboratory is currently involved in an R&D limited partnership. A procedure was invented at Los Alamos by which viruses and bacteria could be quickly identified. A venture capitalist raised $8.5 million through an R&D limited partnership with Prudential-Bache Securities and gave half the money to the lab to develop a commercial prototype. The partnership acquired full ownership of the technology and then granted an exclusive license to a new company. The partnership pays the lab for use of its staff during regular hours and hires lab scientists as consultants after hours. The arrangement took two years and eleven contracts to finalize. The major difficulty was the patent. DOE had to waive its title to the University of California, which operates the lab, and in return the university had to waive its title to the partnership (Brody, 1985).

As a second and perhaps more relevant example, DOE has helped to establish an R&D limited partnership concerning smart home technologies. The Smart House Project of the National Association of Home Builders Research Foundation (NAHB/RF) has enlisted over twenty large electrical and electronic products firms to redesign the residential electrical system. The NAHB/RF has organized these firms

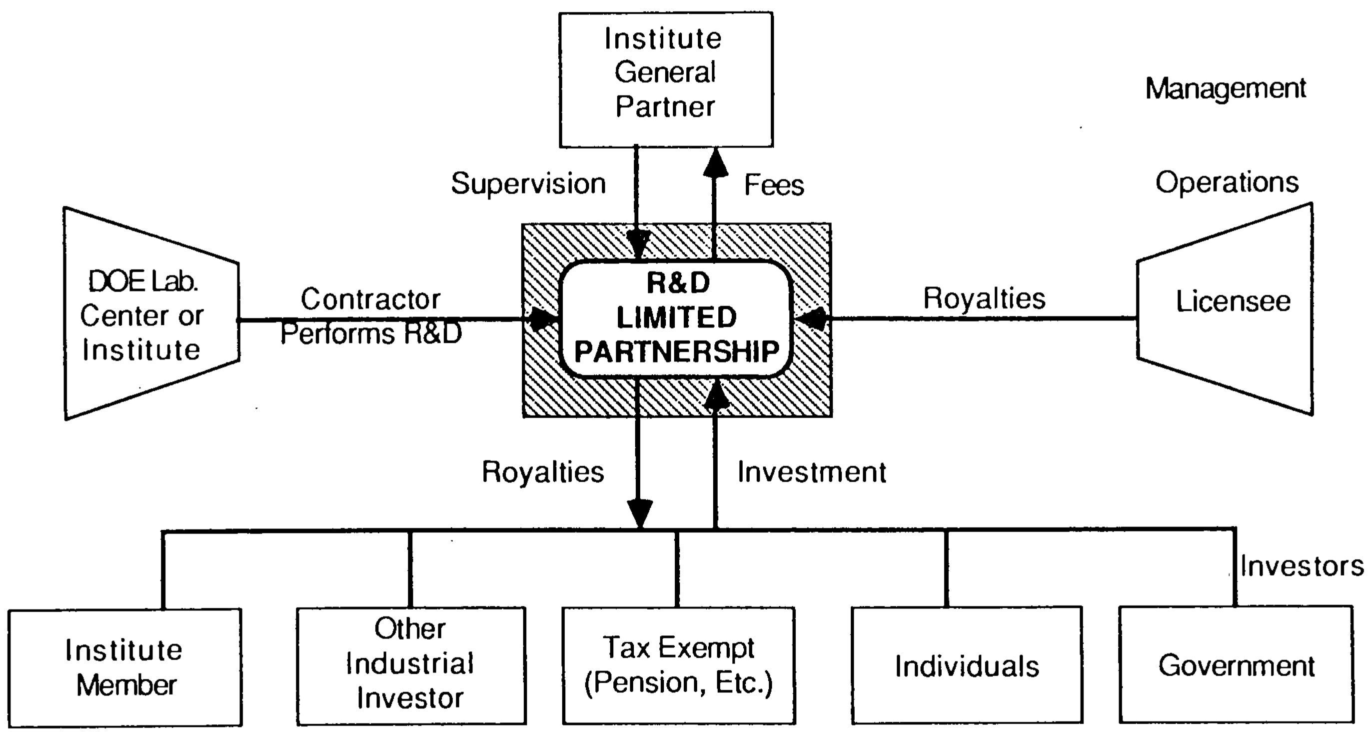

Figure 5.3. Model R&D limited partnership structure.
Source: U.S. Department of Commerce (1983).

into development teams that will apply existing technology to produce a set of compatible products included:

- integrated power-and-signal cabling to tie all home electrical products into a single power and communications network;
- communications-capable appliances, utilities, and home electronics products;
- central controllers to regulate the flows of energy and information throughout the house; and
- a telephone interface to allow information and instructions to be passed to and from the network directly over the phone lines.

The NAHB/RF will oversee the design of the Smart House System and is the general partner. The unique value created by the project comes from coordinating all of these different firms. No one organization produces more than a few of the products involved, so designing a set of products that all "talk" to one another is difficult without cooperation.

Upon completion of design, the firms will license the newly created technology from the Smart House organization for a period of two to three years to produce and sell the products they helped to design. During the licensing period the Smart House organization will coordinate introduction and promotion of the system throughout the country. At the end of this period, the organization will sell the rights to the new technology to the firms to repay the financing and development costs.

DOE helped to support the establishment of this R&D limited partnership by providing some initial seed money. Currently, one ORNL scientist is working full-time on the project, as an employee of one of the limited partners.

5.2.4 National User Facilities

National user facilities are organized specifically to be shared with the entire research community of interest. Such facilities are designed to encourage outside interest and can easily accept industrial users. Examples are the National Pipe Testing Center at ANL built to support BCS's Community Systems Program, LBL's mobile window thermal test unit (MoWitt), and ORNL's proposed Roof Research Center.

The Roof Research Center will be used to conduct research on problems related to the thermal efficiency and durability of low-slope roofs. The major component of the Center is the Roof Test Chamber in which large-scale (up to 12 ft by 12 ft) roof sections can be tested either under simulated climate conditions or under carefully controlled parametric variations. ORNL will manage the facility for DOE with the assistance of a Roof Research Advisory Panel comprised of members from universities, industry, and government agencies. The Panel will provide guidance in setting research priorities, selecting experiments, and establishing a user's schedule for the Center.

5.2.5 Subcontracting

Subcontracts with specific industrial organizations provide another means of encouraging BCS/industry cooperation in the commercialization of a technology process or product. Since these are typically arrangements with single firms or entities, they are discussed as part of the next strategy in Section 6.3.

5.2.6 Other Cooperative R&D Agreements

Researcher exchanges and short-term staff visits are cooperative R&D arrangements which facilitate personal interactions of a technical nature. Johnson Controls has situated a research associate at NBS to collaborate in their systems and controls program. The Innovative Refrigeration Equipment Program at NBS has developed a close working relationship with industry as a result of frequent industry visits from firms such as Carrier, York, DuPont, and Trane.

Electronic bulletin boards and electronic researcher networks are other examples of mechanisms for keeping public and private sector researchers informed of each other's accomplishments, and for stimulating collaboration. LBL's Daylighting Research Network is an example, involving members of architectural schools around the country. NBS has set up and operated an electronic bulletin board to transfer information about its HVAC control systems simulation program (HVACSIM).

Cooperative research may involve a formal contract between a DOE National Laboratory and industry, universities, or individuals through which the lab conducts research on a full or partial cost-recovery basis. While less common, DOE National Laboratories have conducted research that is fully funded and directed by industry. Joint sponsorship is more typical and may take many forms. For instance, a contractual arrangement may involve donation of money to a lab in support of laboratory R&D. For instance, NFC has provided support for LBL's testing program; EPRI, GRI, and BCS have co-funded the development of a data base on the concentration of indoor air pollutants; EPRI has provided financial support for NBS's refrigerant mixtures research; and private firms have provided support for field application of low cost data acquisition methods developed at PNL for commercial buildings.

Another possibility is cost-sharing through the exchange or use of equipment and the sharing of performance data. LBL's MoWitt, for example, has been used as a test facility by EPRI to study lighting thermal impacts. Carrier has provided air handling equipment to be used in NBS's systems and controls program. Cost-sharing may occur when industrial partners provide some of the labor requirements of a program. The leveraging of funds, skills, and special equipment from collaborators in these types of arrangements can significantly reduce project costs to BCS. Additionally, retention of federal march-in rights as well as involvement of the industrial collaborators from the beginning of the project encourages prompt commercialization of project developments.

5.3 THE APPLICABILITY OF DIFFERENT TYPES OF COOPERATIVE ARRANGEMENTS

Different cooperative arrangements are appropriate for different stages of the innovation process, due to the level of involvement companies are willing to undertake and the skills and resources needed over time. Figure 5.4 suggests the time frames over which particular cooperative arrangements are most relevant.

During the earliest stages of development, where technical uncertainties are the greatest and the market opportunities are unclear, risks are often too great to gain commitments from a single industrial partner to participate in a joint venture with a federal laboratory. Subcontracting to a company may be a more appropriate means of generating industrial collaboration. Industrial review panels are an alternative mechanism for ensuring industry involvement.

As a technology matures, the technical risks are typically reduced by demonstrating the feasibility of the innovation. However, because the technology has not been completely adapted to industrial applications, a large element of uncertainty remains in the area of advanced engineering development. At the same time, the market potential should begin to clarify. If the opportunities appear large enough, companies should become more willing to make a strong commitment to further development of the technology. At this stage, industrial partners should at least share some of the financial burden. In situations where technological developments attract interest from more than one company, research consortia are an option for forming collaborative relationships. Such situations are most likely to occur where the market applications for a new technology are immediately apparent and the market potential is commonly perceived to be great. Because the financial burden for development is shared among a number of companies and/or the perceived market opportunity is very large, higher levels of technical uncertainty may be tolerated than is required for a joint venture. Such sharing will also dictate that the research be of generic interest to the majority of the participants. Thus, early stage research on a relatively general area of technology is most often supported. Each participating company, however, will likely want to develop its own proprietary interests, and not want to share the knowledge or rights to those products or processes. Research, therefore, is not likely to be supported by consortia past a stage in which a product or process can be initially evaluated.

Once a technology has reached a state of maturity, an industrial partner should be willing to bear most, if not all of the financial burdens of further development. This may take the form of fully sponsored work at a national laboratory, for which a company protects its intellectual property rights through ownership of resulting patents. Research and development limited partnerships are also appropriate at this stage, when products or processes that would result from advanced applications engineering are already clearly apparent.

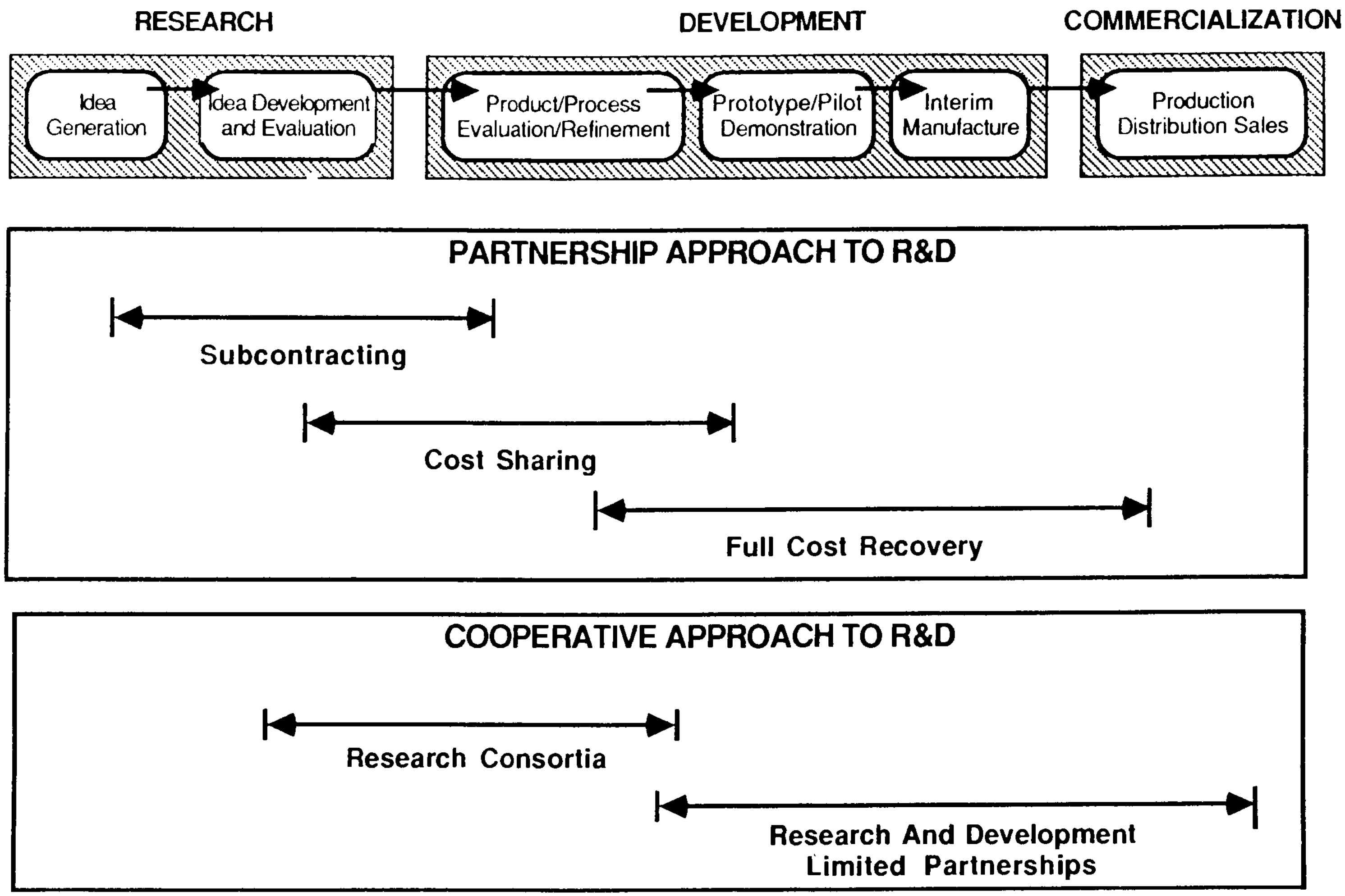

Figure 5.4. Applicability of various cooperative and partnership arrangements. Source: Soderstrom, et al. (1985)

6. FOCUS ON INNOVATORS AND LEADERS AS INDUSTRIAL PARTNERS

6.1 INTRODUCTION

In R&D programs sponsored by BCS, laboratory/industry cooperation frequently involves a group of firms. Industry review panels, for instance, are commonly employed, and they typically involve multiple firms, university researchers, and trade associations. Through such mechanisms, R&D results are made known to the research community at large, and no one firm or organization is given a competitive edge by having early access to, or ownership of, the results.

Under certain circumstances, BCS may find it useful to concentrate particular types of attention on specific firms in an industry or on single trade associations in order to transfer technological developments. In so doing, the single firm or organization has a greater incentive to develop and vigorously market a technology. This strategy capitalizes on the fact that firms are motivated by profitability and generally must be offered patent rights or exclusive licenses to inventions which they eventually offer as new products. Firms are generally reluctant to contribute to a commercialization process to any great extent if competing firms have equal access and ownership to the underlying intellectual property.

6.2 TYPES OF JOINT AGREEMENTS AND INDUSTRIAL PARTNERS

There are a variety of mechanisms through which work can be conducted in collaboration with a single firm or organization. Possibly the most important are subcontracting, researcher exchanges, nondisclosure agreements through which information is shared on a limited basis, and exclusive licensing. For each of these cooperative mechanisms, an industrial partner must be selected. Where a subcontract is issued from a national laboratory to a firm, the selection will typically involve a competitive bidding process initiated by a Request for Proposal (RFP). In other cases a less formal selection process may occur. In all instances, there are particular characteristics of industrial partners which will contribute to successful technology transfer. These are discussed below.

6.2.1 Access to Capital

The firm should either have the capital necessary to successfully undertake development and marketing of a new product, or should be able to readily obtain the capital in stages, as needed. Credibility and a record of successful performances will be helpful in this regard.

6.2.2 Supply and Product Distribution Systems

If the industrial partner is to manufacture and distribute the technology as a new product, then it is helpful if it already has a fully developed supply network and has access to a product distribution system to reach potential markets. If the technology creates a new market niche and requires establishment of a new product distribution network, then access to market planning and financial resources is more critical.

6.2.3 Experience in Developing and Marketing New Products

A firm with a reputation for working with new products and experience in bringing new products into the market should be sought. Large, more established firms may have well-defined product lines which they are reluctant to disrupt with a new activity, and their internal bureaucracies may be more burdensome.

6.2.4 Other Resources to Support the Innovation Process

Many infrastructural and organizational resources contribute to successful commercialization of new products, including warehouse and retail facilities; market research, management, and control systems; and personnel training and development programs. These help to take the innovation through the entire commercialization process.

Most of these criteria suggest that larger firms are better suited as industrial partners in the technology transfer process. Indeed, large firms have been found to be more innovative than smaller firms when the new technology is a process or represents an incremental change to an existing product. Further, larger firms tend to act as industry or opinion leaders in the innovation diffusion process, initiating trends which are followed by others (Rogers, 1983). An industry leader need not be an innovator itself; that is, it may not be among the first firms to adopt new product or process innovations. However, its adoption of some new technology is interpreted by other firms in the industry as an indication that the technology is likely to be successful.

Small firms, on the other hand, are particularly innovative when technologies represent radically new products. They are willing to introduce a new product when a market is still small and financial risks are great. Their innovativeness is sometimes driven by a need to find entry into a market that is already dominated by a set of established firms. Because of their typically low profile in an industry, their introduction of a new product or process carries at most only a weak message to other firms. Innovative small businesses may be appropriate industrial partners in certain circumstances, but it may also be difficult to identify them.

One instance in which small firms developed a new product in cooperation with a DOE laboratory is the high efficiency solid state ballast. Lawrence Berkeley Laboratory (LBL) extended an RFP to the lighting industry for subcontracted R&D and 50% cost-sharing, with the firms to receive patent rights. Only small firms responded, subsequently developing the product and entering the market with it. More recently, large firms have added the high efficiency solid state ballast to their product lines. In addition to subcontracting this R&D effort, LBL assisted in the technology transfer process by acting as a communication channel between large and small firms, and providing informal consultations to firms.

Research and development for which energy savings are believed to exist but are difficult to demonstrate with any precision may not attract the interest of private firms, because the risk associated with their marketing is too great. Nonprofit organizations, utilities, and public agencies may be appropriate partners in such cases. As an example, there has been mutually profitable interaction between LBL's ventilation R&D program and the production and sales operations of nonprofit retrofit firms. The contractual arrangements have been informal and there has been free information exchange. The nonprofits are able to use new techniques of building ventilation and LBL receives new performance data.

6.3 INDUSTRY LEADER/INNOVATOR STRATEGIES

The activities in which BCS and BCS-sponsored laboratories can expect to profitably interact with private firms to bring new technologies to the market will vary with the characteristics of the technology (including stage of development), the relevant industry audiences, and the market. The following sections note some possible types of one-on-one interaction with private firms designed to bring new BCS-supported technologies into the market, beginning with interactions as early as the R&D planning stage and including possibilities involving the actual R&D and the testing, manufacturing, and marketing phases.

6.3.1 R&D and Project Planning

Many R&D programs capitalize on industrial review panels to assist in the development of R&D agendas and project planning. There are some limitations to relying on such panels as the sole source of industry input, however, because they involve open forums in which the advice and information provided by any one firm is shared with potential competitors. Such openness may make firms reluctant to be candid. Several supplemental activities may be used to circumvent this problem.

For instance, a DOE laboratory can sign nondisclosure agreements with individual firms in order to learn about their research. The laboratory must then protect this information against external dissemination, but can still use it internally in R&D and project planning. Such arrangements are currently in use at ORNL.

A second possibility is to assign a DOE laboratory staff member to spend a period of time working in the research facility of an innovative firm. While the costs of this may have to be fully borne by BCS, it can be an effective way of obtaining a detailed understanding of an area of research in instances when alternative learning modes (e.g., published literature) are unavailable.

6.3.2 Conducting R&D with an Industrial Partner

While extensive attention has been given to laboratory/industry/university consortium research, there is considerable scope for laboratory contracting with individual private firms to conduct specific R&D activities. There is a risk that such federal support of research, with the results being privately owned, can cause public sponsorship of research which the private sector would have done on its own. However, appropriate structuring of R&D contracts can reduce much of that risk.

In particular, specification of minimum cost sharing for large firms conducting the contracted research is useful in this regard. A firm which bids on an RFP will have some idea of the value to it of conducting the research, for any particular cost share. If the government requires the firm to take too high a cost share, the firm may decide that the research is not cost-effective and consequently do it on its own to avoid dealing with government bureaucracy--or forego the research altogether. On the other hand, the government should not impose too low a level of cost sharing or it will pay firms to do research they would have done anyway. DOE currently requires that large corporations (over 400 employees) share at least 20 percent of the R&D costs in order to petition for patent waivers.

Single-firm contracting for R&D can get BCS-supported technologies at relatively early stages in their development to parties with incentives to actively market them. Sometimes a small level of support to a firm can allow a researcher to demonstrate to the firm's R&D management that a particular area of research is profitable given the firm's R&D planning horizons and requirements for appropriability of research results. Such public support can lead to elimination of some of the problems associated with the "not invented here" syndrome, by introducing an R&D topic into a firm's agenda at an early stage. This method appears to be the way that R&D on high efficiency light bulbs entered into the research agendas of several large firms.

Advanced patent waivers will be necessary to induce the typical private company to accept such contracts, but the federal government can retain rights to the technical data generated in the course of the research. For example, Westinghouse under subcontract to ORNL, has developed a two-speed air-to-air heat pump with an improved annual performance factor. Another example of such an arrangement is the subcontracted R&D conducted by Friedrich for Brookhaven National Laboratory. Friedrich is conducting R&D on optimizing the mechanical package of a ground coupled heat pump and intends to manufacture a new heat pump as the result of this work.

Generally, the types of R&D which would be contracted to single firms would be product and production oriented, and not basic research or consumer-oriented research. R&D with broad technological applications is more appropriately performed by DOE's laboratories, so that the results can be made available to all of the relevant industries.

6.3.3 Testing New Products and Analytic Models

Lack of appropriate test information can be a major barrier to adoption of new products and processes. Firms and consumers often must rely on manufacturers' test results, but they tend to do so with skepticism. A strategy to address this problem is for federal research laboratories to conduct tests of product performance. Where products are on the market, testing can take place without industry collaboration. However, it may be useful to have a company representative oversee the testing to forestall accusations that the tests were improperly administered. It may also be possible to generate industry cost-sharing for the testing. In most instances, such cooperation is perhaps best done with the involvement of many firms.

Cooperative agreements with a single trade association can capitalize on advantages of both the industry leader and cooperative approaches.

By working with an association, it may be possible to gain access to greater research support than with a single firm. At the same time, the association can retain rights to resulting patents and is thereby motivated to actively commercialize results.

An example of such a situation is EPRI's sponsorship of a cool storage test facility at ORNL. The Electric Power Research Institute has committed $1.2 million over a two-year period to pay for the costs of constructing the new facility. Oak Ridge National Laboratory, in turn, is contributing some existing equipment which will be reconfigured for inclusion in this facility. The facility will be owned by DOE and managed by ORNL. The Electric Power Research Institute will have the patent rights to resulting inventions, which they can then license to help recover their costs.

A counter-example, where working with a single trade organization may <u>not</u> result in the appropriate incentives for commercialization, is given by the Gas Research Institute (GRI). The GRI typically requires ownership of patents resulting from R&D it sponsors, and makes the inventions available through <u>nonexclusive</u> licenses to users. The fact that inventions are available to a widespread audience reduces the incentives for firms to conduct R&D for GRI or to develop or improve their products using the new information.

When analytic models of processes or equipment performance are being tested, it may be cost-effective to have firms provide equipment performance information, particularly where this information is extremely expensive to generate. Sometimes this requires nondisclosure agreements with individual firms in order to protect the firm's products. Such agreements have been employed in tests of ORNL's heat pump model, a computerized design tool. One company has agreed to provide ORNL with indicators of the performance of their heat exchangers in return for receiving detailed results of the modelling. Another company is providing ORNL with compressor performance maps which will be used in the heat pump model. The nondisclosure agreement used in this instance provides that the firm will receive the model results immediately, while others will have to wait for the results to be published. Similarly, ORNL has signed an agreement with Niagra Mohawk to supply ORNL with field data on ground-coupled heat pump performance in exchange for help in instrumentation and analysis.

6.3.4 Manufacturing a New Product

If the technology development process has involved collaboration with an industrial partner who owns the relevant patent(s), then the subsequent commercialization steps should follow naturally and quickly, if the technology is seen to be profitable. Retention of federal march-in rights can further encourage prompt commercialization of such project developments.

The case may arise in which DOE retains ownership of a patent and the technology has been brought to the point at which a private sector manufacturer is needed to commercialize it. Licensing becomes the key mechanism. In return for seeing a BCS-supported product into the market at some risk and expense to itself, a private firm will almost certainly require an exclusive license.

Choice of a firm to manufacture the item is important at this point, and the considerations mentioned in Section 6.3.2 become important, including: access to capital, existence of established supply and product distribution systems, experience developing new products, and access other resources to support the innovation process.

6.3.5 Marketing a New Product

The Office of Buildings and Community Systems does not typically become involved in direct marketing activities, but some of its actions may affect the ability of a firm to establish a new product. Sponsorship of R&D by DOE may enlarge a firm's ability to market a new product by drawing attention to the product or lending credibility to it. This would appear to be particularly valuable for small firms, which may not have established reputations, DOE sponsorship would also be particularly useful when the support occurs during the final stages of product development. During these later stages fewer ambiguities about product character and actual performance exist, so DOE support may be more meaningful as an endorsement.

6.4 WHEN TO WORK WITH ONE VERSUS MANY INDUSTRIAL PARTNERS

Cooperative arrangements involving many industrial, university, and other collaborators appear to be most appropriate under the following circumstances.

- the technology is embryonic and the risks of cost-sharing are too great for a single company to bear
- the R&D is not oriented to the development of new products but rather involves product testing or consumer use issues
- when the research has broad technological applications and will eventually affect two or more different industries or product lines
- similarly, when the ultimate market for a technology is large enough to support the involvement of many firms
- when companies in an industry are cash poor and need to join together to support R&D

When one or more of these conditions is not satisfied, working with single industrial partners may be a better approach. The two strategies are not necessarily incompatible; in some instances they can be combined. Recall the suggestion that R&D and project planning may be conducted with the assistance of an industrial review panel as well as nondisclosure agreements and researcher exchanges. However, it is likely that the nature of the technology, characteristics of the industry audiences, and market considerations will dictate a dominant emphasis on either a multiple or single firm approach.

7. WORK THROUGH TRADE AND PROFESSIONAL ASSOCIATIONS

7.1 RATIONALE FOR INVOLVEMENT OF "BROKER ORGANIZATIONS"

A variety of trade and professional associations representing the architectural, design, engineering, building, product and materials communities can act as "broker organizations" throughout the technology transfer process. Since many of these organizations have continuing contact with their members, have their members' confidences, and speak their language, these broker organizations provide DOE and other federally sponsored research programs with a useful information exchange system. These organizations serve as channels of communication for bringing relevant R&D-related information to the attention of their various constituencies. Through them user needs may also be assessed, research results disseminated, and the technology transfer process evaluated.

Networking and coordination between individuals, firms, and public entities, such as performed by trade associations, is important for three other reasons:

- users of energy technologies may have similar problems allowing for wider diffusion of solutions

- aggregating the demand of smaller technology users may be necessary to achieve sufficient economies of scale or market pull

- coordinated innovation within an industry may be needed when fragmented supplies of service and technology components are highly integrated into a production process. Improving one component can often occur only if other components are modified to accomodate the change.

Such use of building industry associations has been urged by the industry itself, which generally feels that its information channels are well suited to such a task (American Institute of Architects Foundation, 1983). Broad evidence of public support for the involvement of broker organizations became apparent at the public hearings held by DOE across the nation in the fall of 1979 and 1980 in relation to the Building Energy Performance Standards Program. The leading building professional societies and associations, such as the American Institute of Architects, the National Institute of Building Sciences and the National Association of Home Builders expressed strong interest on behalf of their members in having access to and being informed about the results of DOE's building energy research. As evidence of their continued interest in this program, many of these groups have worked with DOE on program review panels, in cost sharing arrangements, with BCS, and in a variety of other ways (Brown et al, 1985).

The DOE can catalyze and enhance its technology transfer process by leveraging its results through the use of such organizations and their resources, and by supplementing this existing system only where weaknesses or gaps are discovered. The creation of an entirely new system of technology transfer would only lead to costly redundancies.

Trade and professional associations can provide a channel for the federal sector to learn the needs of industry and to share federal research and/or information equitably with a group of industries (FLC, 1982). However, Eliot and Downing (1982) also note the multiplicity of roles of the broker organization as a demanding and professional carrier of technology--at different times a facilitator, mediator, expediter, disseminator, catalyst, organizer, coordinator, monitor, evaluator, and promotor.

Use of broker organizations to extend government's own technology transfer process has been documented to be advantageous (McEachron et al, 1978). In a two-year study funded by the National Science Foundation, Bingham et al (1978) examined the contributions of public service professional organizations as intermediaries in transferring technology to city governments. Bingham questioned organization staff members on the effectiveness of transfer techniques used in each phase of the transfer process which he identified as: (1) "most useful in helping your target population perceive a problem or shortcoming in his city or department," (2) "most useful in providing data to your target population on the effectiveness or efficiency of an innovation," and (3) "most useful in helping your target population create a climate for acceptance of an innovation among elected officials, citizens, and his employees and recognize obstacles to adoption."

Their responses suggested general satisfaction with techniques used by the organizations to help local officials perceive problems and evaluate innovations. There was a general dissatisfaction, however, with transfer techniques used in the final acceptance phase of the innovation process.

7.2 POTENTIAL LIMITATIONS OF A BROKER ORGANIZATION STRATEGY

While trade and professional associations have been suggested to be useful information exchange mechanisms, there may be particular limitations to individual broker organizations. Broker organizations may have a limited membership, thereby representing only a portion of their potential constituents. Some represent only particular regional sectors of the building industry. Others are limited by their topical specializations. Many trade associations have "vested interests" and exist solely for the purpose of political lobbying. As Eliot and Downing (1982) note, broker organizations have a tendency to emphasize a narrower view of the overall industry because they are chartered to represent a specific industry segment.

Within any of the broker organizations there are potential problems related to communication breakdown. A broker may have limited outreach resources; small staff, few publications and the general lack of established communication links both to and from organization members inhibit the exchange of innovative ideas and information. Not only the existence, but also the credibility and reliability of these communication networks within the organizations are important considerations when assessing the value of broker organizations as information exchange mechanisms.

Broker organizations may or may not possess the financial resources to provide incentives such as support for feasibility studies or seed money to members who adopt a new technology. They vary in terms of their ability to conduct collaborative R&D and the way they license patents. (Recall the different approaches taken by EPRI and GRI as described Section 6.)

The number and type of organizations to be included in a broker strategy should be chosen on the basis of the audience and the capabilities of each organization. The goal is to develop a network of broker organizations which, taken together, are able to communicate effectively with the targeted audiences and which can otherwise support the transfer process.

7.3 DETERMINING THE POTENTIAL ROLE OF A BROKER ORGANIZATION STRATEGY

To utilize broker organizations effectively the various brokers which represent constituencies related to the R&D program in question first need to be identified. To determine the potential role of these broker organizations in a transfer strategy, many questions must be considered. For instance:

1. What type of buildings do the brokers cover? Is every region covered? How many members does each organization have? What proportion of the industry does the organization represent? Are there regional divisions within the organization?

2. What are the transfer mechanisms used within each broker organization? How does each organization determine the utility and relative priority of the innovations that are selected for promotion? Which individual makes that decision?

3. What energy technologies are of interest to each broker organization and its constituency? Does the broker have a product or process orientation? Is it interested only in energy technologies involving incremental changes? Does it deal with construction materials, appliances?

4. In what stage or stages of technology development and use is the broker organization and its constituency involved? Some brokers are involved in the planning and design of buildings, some in the actual construction, and others in regulating, retailing and maintaining buildings.

5. Do the broker organization conduct their own R&D? Is there collaboration between the broker organization and other research institutions?

6. What is the brokers organization's credibility and what are its built-in biases? How long has it been organized? Are the broker's information mechanisms reliable?

As a resource for answering some of these questions, Copenhaver (1985) provides a bibliographic data base of broker organizations. Over 450 organizations have been identified--some 400 directly related to the building industry and approximately 55 others of indirect interest such as educational and information-oriented organizations. These groups may be broad umbrella organizations; often their membership is an amalgam of several organizations. Examples of broadly focused brokers are:

- National Association of Home Builders
  (103,000 Members, 220 Staff)
- Building Owners and Managers Association International
  (4,000 Members, 14 Staff)
- Construction Specifications Institute
  (12,000 Members, 25 Staff) and
- American Industrial Arts Association
  (7,000 Members).

In contrast some broker organizations are more specific in focus and deal with a much narrower constituency, such as:

- Drywall Contractors
  (700 Members, 7 Staff)
- Gas Appliance Manufacturers Association
  (275 Members, 26 Staff)
- American Home Lighting Institute
  (450 Members, 6 Staff) and
- Construction Writers Association
  (85 Members).

Most of the organizations covered in the data base are national in scope, but there may be many other regional or local groups covering the same subject areas.

An examination of the transfer mechanisms used by broker organizations is also provided in Copenhaver (1985). The mechanisms cited in this data base are listed in descending frequency in Table 7.1. The most common are conferences or meetings and newsletters. Since these transfer mechanism listings have been obtained from various nonuniform secondary sources, they are only suggestive of actual frequencies.

In comparison, a survey of thirty participants in the 1985 ASHRAE/DOE Roundtable on Technology Transfer (ASHRAE, 1985), including a cross section of these broker organizations, identified 26 technology transfer mechanisms used. The mechanisms most often cited were:

Table 7.1 Transfer mechanisms used by trade and professional associations in the buildings industry

	Transfer Mechanism:[a]	Frequency:
1.	Conferences/meetings	(185)
2.	Newsletters	(180)
3.	Seminars/symposia	(61)
4.	Journals/magazines	(57)
5.	Educational programs and material	(48)
6.	Professional reference manuals	(45)
7.	Awards - mostly internal	(42)
8.	Research	(38)
9.	Books	(35)
10.	Information bulletins	(35)
11.	Surveys (on portion of industry)	(30)
12.	Technical reports	(24)
13.	Standards	(24)
14.	Guidelines/procedures	(23)
15.	Workshops	(18)
16.	Proceedings	(18)
17.	Library	(18)
18.	Statistics	(17)
19.	Legislative information services	(17)
20	Specifications	(15)
21.	Accreditation/certification activities	(13)
22.	Codes/model contracts	(11)
23.	Competitions	(10)
24.	Formal information exchange systems	(10)
25.	Trade shows/exhibitions	(9)
26.	Sponsor of institutes/foundations/etc.	(9)
27.	Speakers Bureau	(8)
28.	Apprenticeship/training	(8)
29.	Scholarships	(7)
30.	Audiovisual aids	(5)
31.	Regional conferences	(5)
32.	Task forces	(4)
33.	Films	(4)
34.	Lectures	(4)
35.	Professional consultations	(4)
36.	Slide shows	(3)
37.	Computer programs	(3)
38.	Fellowships	(3)
39.	Home study courses	(2)
40.	Career guidance	(2)
41.	Internships	(2)
42.	Manpower training programs	(2)
43.	Newspapers	(2)
44.	Videotapes	(2)

[a]Demonstrations, microfilm, magnetic tapes, house plans, and referral services were each cited by one association.
Source: Copenhaver (1985)

- technical journals
- workshops, symposia, seminars
- technical reports
- manuals, handbooks, transactions
- press releases, newsletters, brochures
- technical and standards committees
- guest workers, visiting scholars, student programs, and
- oral and face-to-face contacts

7.4 ARGONNE'S TECHNOLOGY INFORMATION EXCHANGE FOR DISTRICT HEATING AND COOLING

During FY 1984, the Argonne National Laboratory assisted the Community Systems R&D branch with the preparation of a five-year program plan. A major thrust of this multiyear Community Systems Program plan was on technology transfer through a broker organization strategy. Argonne National Laboratory (ANL) obtained the data to complete this task through consultation with trade associations, industrial suppliers, developers, municipal officials and national laboratories.

Presently, ANL is developing a technology information exchange system for District Heating and Cooling (DHC). This technology transfer project, employing the broker organization strategy previously established in FY 1984, is to be completed through a series of four tasks. The first of the tasks designated by ANL is to develop a data base directory of organizations whose areas of interest are important in the research, design and implementation of DHC systems. The second task of the project is to acquire, through interviews with organization representatives, information about each organization's communication channels. This information will be used to develop the structure of a network for disseminating technical information concerning DHC to specialized audiences among the organizations in the DHC directory. The third task of the project is to organize the directory of DHC brokers and the network of communication channels into a computerized data base. The system is to be compatible with existing information systems for other DOE programs and will allow easy updating of the data base and flexible networking for information dissemination.

The final phase of the project will be to test the DHC technical information exchange network. Three recent research projects will be selected and reported through the network. Specialized information in several subject areas wil be abstracted from the research results and sent through the appropriate channels. The result of this project will be an assessment of the technological information exchange system established through the broker organizations related to district heating and cooling.

7.5 AN ILLUSTRATION--BROKER ORGANIZATIONS IN THE ROOFING INDUSTRY

A pilot study was conducted to determine the potential usefulness of a broker organization strategy in a particular sector of the building industry. The roofing sector was chosen for illustration because of its compact, well-defined nature and the small number of relevant broker organizations, resulting in a manageable task. More significant, however, was the timeliness of the topic as the BCS roofing program managed by Oak Ridge National Laboratory is fairly new, and a network involving brokers is only now emerging.

7.5.1 Identification of Brokers

The initial step toward evaluating the broker network was to identify the various trade and professional associations concerned with the roofing industry. The names of each association, as well as their address and telephone number was obtained primarily from Copenhaver (1985) and the Directory of Associations (1984). A list of roofing brokers contacted is given in Table 7.2.

After a list of roofing brokers was compiled, a broker protocol was developed to provide answers to the questions identified in 8.3 as necessary to determine the potential role of a broker strategy. With this protocol it was possible to obtain the needed information in a relatively short period of time, usually 10 to 15 minutes. The roofing brokers were contacted with little or no difficulty and information was easily obtained from a staff member or organization officer.

7.5.2 Results: Information Flows in the Roofing Industry

The initial observation from this pilot study was that an assessment of the internal communication network for a particular sector of the building industry should be based not on apparently reasonable assumptions but rather on verified relationships. For example, one assumed roofing broker, the Asphalt Emulsion Manufacturing Association, reported no contact with the roofing industry. Other roofing brokers, such as the Asphalt Institute, the Gypsum Association and the Steel Deck Institute, reported only mininal contact with brokers that have specialized roofing interests. In addition, broad umbrella organizations for the entire building industry, such as BOMA and NAHB, were found to have only informal ties to particular sectors of the roofing industry.

From responses given to the broker protocol, an interaction matrix for roofing brokers was derived. The information in this matrix was then used to construct the internal network of communication for the roofing industry (Figure 7.1). As previously stated, the appropriateness of a broker strategy is enhanced by the existence of a well-developed information network within the industry sector. From the information collected in this pilot study, the roofing industry sector appears as such.

The National Roofing Contractors Association (NRCA) was identified by all of the roofing brokers contacted as a primary source of roofing information. The NRCA is by far the largest of the roofing broker organizations and is also the most active. Direct flows of information from the NRCA to roofing practitioners include a monthly bulletin, Action Information, and a monthly journal, Roofing Spec.

Table 7.2 Trade and Professional Associations in the Roofing Industry

<u>Roofing Organizations</u>:
Asphalt Institute (AI)
Asphalt Roofing Manufacturers Association (ARMA)
National Roofing Foundation (NRF)
National Tile Roofing Manufacturers Association (NTRMA)
Single Ply Roofing Institute (SPRI)
Steel Deck Institute (SDI)
Roof Coatings Manufacturers Association (RCMA)
National Roof Deck Contractors Association (NRDCA)
National Roof Litigation Center (NRLC)
National Roofing Contractors Association (NRCA)
Roofing Industry Educational Institute (RIEI)
Gypsum Association (GA)
Society of Plastics Industry (SPI)
Roof Consultants Institute (RCI)
<u>Umbrella Organizations</u>:
American National Standards Institute (ANSI)
American Society for Testing and Materials (ASTM)
Building Owners and Managers Association (BOMA)
Construction Specifications Institute (CSI)
Materials Insulation Manufacturers Association (MIMA)
National Association of Home Builders (NAHB)
Thermal Insulation Manufacturers Association (TIMA)

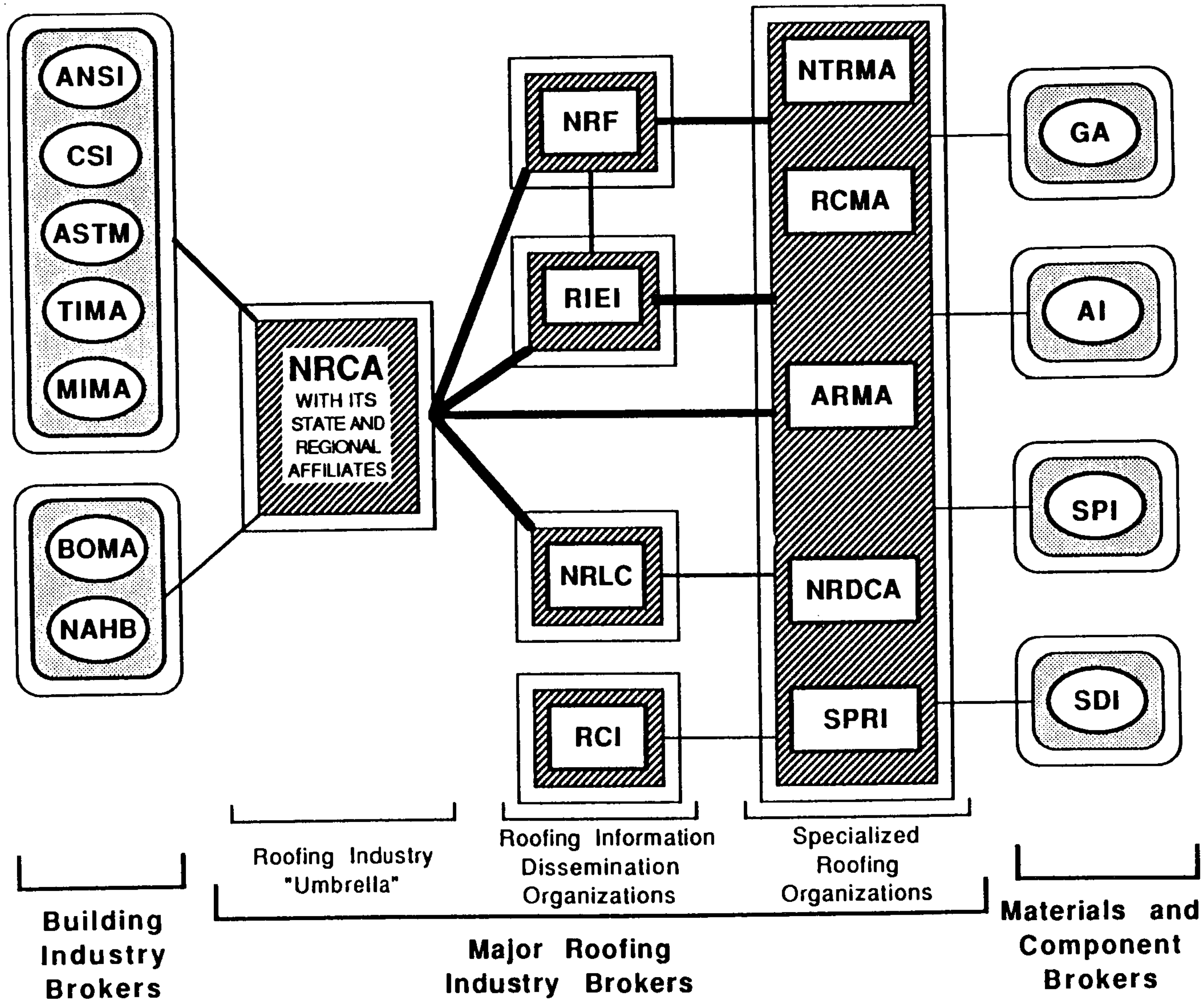

Figure 7.1. Information links among associations in the roofing industry.

The indirect flow of information from the NRCA to the rest of the roofing industry is channeled through three independent, information disseminating roofing brokers: the National Roofing Foundation (NRF), the Roofing Industry Educational Institute (RIEI), and the National Roofing Litigation Center (NRLC). The National Roofing Foundation is a separate, non-profit educational corporation which was established by the NRCA. Formed with the intention of improving the roofing industry, the NRF provides funding for research contracts, grants for educational course development and scholarships to selected students and instructors. Another information oriented roofing organization, the Roofing Industry Educational Institute, is an independent organization which sponsors seminars covering all aspects of roofing. Over 10,000 roofing practitioners from across the United States have participated in RIEI activities since its formation in 1978. These two organizations, along with the NRLC, have been identified by roofing brokers in the various specialized roofing sectors as the primary links between the NRCA and the rest of the roofing industry.

In addition to NRCA, the Thermal Insulation Manufacturers Association (TIMA) was identified by several roofing manufacturing brokers as an important information source. Also noted was the National Bureau of Standards (NBS) which interacts with the NRCA at their Center for Building Technology. Officials at the NRCA, TIMA and the NBS were queried to determine the connection between the primary roofing information sources and the rest of the building industry. Their responses, along with responses from other roofing brokers, indicated that the codes, specifications and standards organizations, particularly the American Society for Testing and Materials (ASTM), were the most significant links between roofing brokers and the rest of the building industry.

7.5.3 Implications

The findings of this pilot study have revealed a well-developed network of communication within the roofing industry. Formal ties between the NRCA and other building industry brokers, particularly the testing and standards organizations, provide the avenues for information dissemination on a large scale. Specialized roofing audiences receive information both directly from the NRCA and indirectly through the NRF and the RIEI. They may also be the direct recipients of information from materials and component brokers.

Much roofing research is proprietary and generally inaccessible to broker organizations. Although these is presently little energy conservation information being dispersed within the roofing industry, roofing brokers appear receptive to any reliable information available. The presence of educational organizations, such as the RIEI and the NRF, within the roofing communication network suggest an industry recognition of the need to develop and disseminate roofing knowledge. Current cooperative activities between these two groups combine the monetary reosources of the NRF with the educational potential of RIEI seminars to develop and promote roofing technology at the college level.

8. GENERATING END-USER DEMAND

8.1 INTRODUCTION

Technology transfer can be fostered by either of two modes: technology push or market pull. The technology push mode emphasizes the transfer of information and technology developed through federal research to the building industry where it may be employed by practitioners or end-users. The market pull mode emphasizes the fulfillment of industry and consumer needs through the planning, execution, and transfer of appropriate federal research relevant to those needs. The primary difference between the modes is the starting point; technology push begins with the availability of a viable technology and efforts are directed at getting it adopted. Market pull begins with the user audience and emphasizes needs assessment activities.

Much of the technology transfer from federal laboratories falls between the market pull and technology push categories. Funding of federal research has a market pull orientation in that it occurs when the nation is seen as facing a problem which might be alleviated or solved by research. The definition of the problems facing the nation which are appropriately studied by federal research institutions is determined by federal agencies, by the Congress, or occasionally by research agencies themselves. One of the principal criteria for conducting federal research involves the public good character of the problem. Such problems are faced by the general public and often involve sizeable total losses, but the solutions often involve the development of new technologies--either new materials, equipment, or techniques--which private individuals or corporations do not find profitable for one reason or another to develop on their own.

Two of the more common reasons for the nonprofitability of such R&D by private agents are high risk and distant payoff of the research and the limited ability of the funding agent to capture a sufficient portion of the benefits to make the R&D investments profitable. Frequently the knowledge embodied in the new development permits other producers to market the same item or a close facsimile very quickly, eroding the market for the original R&D investor. Thus, while much federally developed technology has its origin in the market pull of "national needs," when the federal government tries to place the R&D results into private markets it often has the appearance of a technology push transfer effort: a new gadget or process has been developed by a federal scientist and the sponsoring organization is trying to get some customer to either buy it or try selling it to someone else. This characteristic gains particular prominence in the secondary technology transfer market, where developments designed for one application are marketed for other applications. In this and other instances, adoption of BCS R&D results requires a public role in the active identification, generation, or enhancement of market demand.

8.2 SPINOFF APPLICATIONS OF BCS R&D RESULTS

Spinoff applications involve the transfer of laboratory-developed technologies to industry for applications different from those for which they were originally developed. They have been a key contributor to the success of NASA's R&D program, which has created wide-ranging applications of aerospace technologies. Secondary utilization of federal technologies is a difficult process, however. The greatest barrier to transferring technology to spinoff applications is the identification of market applications. Equally, or even more difficult, is tracking down the secondary utilizations that have occurred. Consequently, there may be a tendency to undervalue the social benefits of federally-sponsored research for which spinoffs are believed to be significant. This is certainly the case for products, but may be equally true with ideas produced during research, which can be applied in research areas that seem unrelated to the area where the idea was initially developed.

Federal agencies including DOE coordinate with the Center for the Utilization of Federal Technology to assist in identifying spinoff applications. The Federal Laboratory Consortium is another resource available for enhancing secondary utilization. These are described in Appendix A.

8.3 GENERATING CONSUMER DEMAND

When a technology or product is actually adopted or used by consumers, it may be appropriate to enlarge consumer demand and improve implementation techniques through consumer information programs, establishment of adoption incentives, or reduction of barriers to appropriate use. An important first step behind generating market demand is to identify the potential market for the product and then gain an understanding of why the product is not being used. For example, if the initial cost of an investment is the primary barrier preventing its widespread adoption then subsidies may be effective. However, if concerns about health or comfort are the primary barriers, then subsidies may not be effective. Many building technologies--individual pieces of equipment, equipment systems, or materials--may be sufficiently complicated that the average person buying a house in which these technologies are options may be unable to evaluate their benefits and costs and may be equally unprepared to take the word of an interested salesperson, realtor, or contractor. Federally-provided information probably would be perceived as trustworthy and could establish a more solid knowledge base for wider consumer demand for technically complicated new buildings products.

One reason why many conservation measures may not be adopted in the residential and commercial sectors is that the resale market for conservation measures does not work efficiently. When an owner sells a home or building, the selling price may not be increased by an amount equal to the present discounted value of the future saving generated by the conservation investments installed in the building. One way to deal with this market failure is to aid the market in performing this function, perhaps by promoting an energy rating system to provide the necessary information to facilitate a resale market.

Consumer-oriented information programs can serve a variety of purposes (Connor, 1984):

1. create awareness of potential benefits from energy conservation;
2. educate as to the array of options generally available;
3. provide specific information on costs and benefits of individual options for a specific type of application or level of investment;
4. provide a basis for comparing costs and benefits of alternative options for specific applications; and
5. provide a basis for identifying quality and reliability of equipment, products, and contractors.

The following list suggests some of the mechanisms which can be used for achieving each of these purposes:

1. AWARENESS:
   - television and radio announcements
   - fairs, exhibits, and demonstrations
   - newspaper and magazine articles
   - utility bill enclosures

2. GENERAL INFORMATION
   - hot lines
   - booklets and pamphlets
   - fact sheets
   - workshops and conferences
   - catalogs and directories

3. SPECIFIC INFORMATION
   - audits
   - monitored demonstrations

4. BASIS FOR COMPARISON
   - home rating systems
   - appliance labels
   - directories of standard test results
   - simple decision tools such as the appliance slide rule

5. BASIS FOR IDENTIFYING QUALITY, RELIABILITY, AND ACCURACY
   - third-party certification process
   - warranties with third-party backing

In selecting among the various possible mechanisms for consumer information, the following questions are relevant. Is the mechanism appropriate to the desired purpose? Will it support normal market functions? Are resources adequate for carrying the program out effectively? Are incentives and mechanisms fair to various sizes of businesses and flexible enough not to hamper innovation (Connor, 1984)?

The Conservation and Renewable Energy Inquiry and Referral Service (CAREIRS) is a DOE-sponsored information center which provides information to consumers. Through its toll-free telephone lines and post office box, CAREIRS is designed to handle consumer requests for information on renewable energy technologies and energy conservation. A computerized letter response system is used in combination with publications. Referrals to other organizations are also provided as needed.

The Office of Buildings and Community Systems is working with CAREIRS to develop fact sheets and paragraph responses on BCS R&D areas to be used by CAREIRS and other organizations. Appendix A lists the existing and forthcoming fact sheets relevant to BCS. Appliance labels, home energy rating systems, and other consumer decision tools have also been developed with BCS support. Perhaps more influential than these efforts, BCS has worked closely with utility conservation programs, particularly RCS and CACS. Collaborating with the utility industry to accelerate improvements in energy efficiency would appear to be mutually beneficial. Coordination with the financial industry as a means of generating consumer demand would also appear to have great potential. Information on operating costs of equipment and materials used in houses could influence the terms on which financial institutions are willing to make mortgage loans.

Adoption incentives include such programs as investment tax rebates or credits and direct price subsidies. In any event, the DOE is not generally able to create or otherwise affect these incentives. Such efforts can produce a wide and surprising array of unintended results and generally should be used as last resorts to correct market failures.

8.4 STIMULATING THE ADOPTION OF KEY FIRMS

Sometimes the introduction of a new technology hinges on a success story with a prominent user--this user, in effect, playing the role of a key firm. The term key firm refers to a firm in its role as a consumer and describes a firm whose patronage is widely considered an important endorsement of a product or process. Public agencies can also act as key adopters in the sense that their purchase or adoption of some new technology or program is considered a trend-setting event by other consumers or even other potential manufacturers and sellers. Indeed, some states and counties are known as particularly innovative public agencies whose technology choices are watched and often followed by others.

The Cooperative Extension Service has been successful at capitalizing on the key roles of "opinion leaders." Leaders in the farming community are identified by County Extension agents through a variety of means including their roles in trade associations. The agents then communicate personally with these farm operators in order to persuade them to try new farming technologies. This strategy capitalizes on the fact that households and individual consumers (and, indeed, many firms) will not adopt a new technology until a credible source of information can personally demonstrate the technology's merits.

When the technology in question is a building product which could be used equally well in buildings occupied by a firm in practically any industry, the criteria for targeting firms have less to do with the industry to which the potential user belongs than with the individual firm's characteristics. One recommendation of a 1984 DOE-sponsored colloquium on automatic daylighting controls in office buildings illustrates this point. It recommended concentrating on major building tenants such as IBM, arguing that the specification of automatic controls by such influential corporations will go a long way towards establishing industry-wide acceptance.

8.5 CONCLUSION

End-user demand is generated by breaking down barriers to technology utilization. Lack of information is one key barrier. The provision and simplification of information so that an end-user finds it useful is a large component in the strategy of generating or boosting final demand for new building technologies. This process involves providing multiple messages on the same topics, differing in level of detail and intended audience. Additionally, end-users are directly affected by a number of intermediaries such as savings and loan associations, so a strategy of stimulating end-user demand can appropriately include targeting relevant information at these secondary audiences. Finally, readily identifiable adopters can provide important nonverbal information by their own purchase behavior.

Another key barrier to technology utilization relates to financing. Availability of capital may pose a significant obstacle to small firms. The provision of low-interest loans or shared savings and third-party financing may be effective in such instances.

This strategy often involves relatively "low tech" and less expensive activities than strategies which include substantial coordination among organizations. As a drawback, however, verification of effectiveness may be elusive, a characteristic of educational investments in general. On balance, though, end-user demand efforts are a useful complement to strategies which operate further upstream in the R&D technology transfer process. They are most appropriate when there actually is market potential. It may be that the government wants to create market potential because it wishes to increase conservation for national security reasons; but strategies such as providing information and targeting key firms will be successful only if there actually are some unrealized gains to be obtained.

9. CONCLUSIONS

A review of the technology transfer programs of different federal agencies documents that a diversity of approaches exists (Hough, 1975). Similarly, the technology transfer activities undertaken at each of DOE's laboratories differ substantially. It is the conclusion of a considerable amount of research and practical experience that technology transfer approaches are most effective if tailored to the needs of the specific technological developments being advanced and the audience segments being targeted. Thus, no single technology transfer strategy is appropriate to all of the audiences and R&D products of DOE's Office of Buildings and Community Systems. At the very least, each BCS R&D program would benefit from a customized technology transfer approach. Nevertheless, there are several "rules of thumb" that cut across the individual needs of specific programs. A few of these are discussed below.

The uninterrupted availability of oil supplies over the past several years and the moderation of energy price increases has sent signals to consumers and decision-makers in the buildings industry that the "energy crisis" is over. As a result, it is becoming apparent that efforts to promote energy-conserving technologies must emphasize benefits other than BTU savings. The improved ambience of daylit spaces and the lower first costs associated with installing down-sized HVAC systems in "tight" buildings are examples of benefits which are likely to be more influential than estimates of energy saved. Successful technology transfer requires that an R&D product have intrinsic value and that these values be effectively communicated to potential users.

Active technology transfer programs are more effective than passive ones. Transfer activities should involve more than simply making information available to those who seek it. Information should be tailored to meet the needs of specific user groups and disseminated through those channels which users normally employ.

In addition to information dissemination, successful technology transfer involves the management of intellectual property, including patented inventions, copyrights, technical data, and rights to future inventions. When the public can best benefit from an invention through commercialization of a new product, the exclusivity necessary to protect the investment from copiers should be provided. Most federal technology transfer programs concentrate on information exchange and largely avoid intellectual property transfers.

Early user involvement in an R&D project increases the likelihood of successful technology transfer. This reflects the fact that market needs are more critical than technological opportunities in stimulating innovation (Myers and Marquis, 1968; Myers and Sweezy, 1982). By actively involving trade and professional associations, a consortium of firms, or a single industrial partner in planning, conducting, and evaluating R&D programs, it is possible to achieve the early and sustained industry involvement that is necessary for successful technology transfer.

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APPENDIX A

INSTITUTIONAL RESOURCES AVAILABLE TO BCS

Index to Appendix A

<u>Commercial and Apartment Conservation Service (CACS)</u>
Office of State and Local Assistance Programs
U.S. Department of Energy
1000 Independence Avenue, S.W.
Washington, D.C. 20585
(202) 252-1650

CACS is often characterized as the extension of the Residential Conservation Service program to small commercial buildings and large apartment buildings. CACS was established in 1980 by the Energy Security Act. Final regulations to implement it became effective in December 1983 and require large gas and electric utilities to offer on-site energy audits of existing small commercial and multi-family buildings. According to DOE estimates, approximately two-thirds of all apartment and commercial buildings are eligible. The CACS regulations specify 12 energy conservation measures for consideration in a CACS audit, such as replacement of inefficient air conditioners and use of energy recovery systems and 12 additional no-cost or low-cost O&M procedures

Conservation and Renewable Energy Inquiry and Referral Service (CAREIRS)
P.O. Box 8900
Silver Spring, Maryland 20807
(215) 448-1538
(800) 523-2929

CAREIRS is a central information source which responds to public inquiries over a toll-free number, and provides general information on renewable energy technologies and energy conservation. A computerized letter response system is used in combination with publications. Referrals to other organizations and people are also provided as needed.

BCS is working with CAREIRS to develop, revise, and update fact sheets on BCS R&D areas to be used by CAREIRS and other organizations. Fact sheets currently exist for the following topics:

Tips for Energy Savers
Indoor Air Pollution
Insulation Fact Sheet
Air-to-Air Heat Exchangers
Appliance Labelling
Caulking and Weatherstripping
Passive Cooling Techniques

The computerized letter response system uses a paragraph file keyed to particular topics. A single entry in the paragraph system can be one paragraph or 1-4 pages consisting of multiple paragraphs. Entries are added or updated biweekly. Some of the energy conservation topics covered in the paragraph response file include:

Energy-Efficient Appliances
Heat Pump Water Heaters
Fans and Ventilation
Superinsulation
Vapor Barriers
Shading Techniques
DOE's Innovative Concepts Program

Energy Extension Service (EES)

Richard Brancato
Energy Management and Extension Division
Office of State and Local Assistance Programs
U.S. Department of Energy
1000 Independence Avenue, S.W.
Washington, D.C. 20585
(202) 252-2344

The purpose of the Energy Extension Service is to connect small-scale energy users such as homeowners, small business, local government and public institutions with information and technical assistance to use conservation measures and renewable resources. The program has been active in all 50 states since 1980, although activities have been substantially reduced since 1981 due to funding limitations. The program is managed by "State Energy Offices." A wide variety of informational and technical assistance activities have been carried out by EES agencies, including demonstrations of commercially available energy conservation/renewable energy technologies, workshops, energy audits, and technical publications.

Energy-Related Inventions Program (ERIP)

Office of State and Local Programs
U.S. Department of Energy
1000 Independence Avenue, S.W.
Washington, D.C. 20585
(202) 252-9104

The Energy-Related Inventions Program is operated by the U.S. Department of Energy and the U.S. Department of Commerce, National Bureau of Standards (NBS). It is intended to stimulate innovation in the energy field by individuals and small companies.

The NBS evaluates all submitted inventions and recommends for support those that are promising to the DOE. The evaluation criteria are technical feasibility, degree of energy impact, commercial potential, and intrinsic technical merit. DOE then reviews recommended inventions to determine whether federal assistance can be provided. If the criteria are met, the terms and conditions are negotiated and a grant is awarded. Most often support takes the form of a one-time-only cash grant and technical assistance in developing linkages with the private sector.

Important characteristics of this program include:

- a target audience limited to individuals, inventors, and small companies with energy-related inventions;
- a broad definition of "invention" that permits consideration of innovations as well as inventions;
- acceptance of technologies at any stage of research and development except "idea generation" and "full commercialization";
- a small, professional staff with technical backgrounds and private sector experience;
- in-depth evaluation of the intrinsic technical merit of inventions and;
- NBS evaluation and DOE financial help either by a small grant used for a task designed to move the invention closer to commercialization or by assistance in obtaining private-sector financial support.

Federal Energy Management Program (FEMP)
Office of State & Local Programs
U.S. Department of Energy
1000 Independence Avenue, S.W.
Washington, D.C. 20585
(202) 252-9467

The Federal Energy Management Program was established to reduce energy consumption in the Federal government by using energy more efficiently, altering the mix to reduce dependence on imported fuels, and increasing the use of renewable resources. FEMP provides technical guidance and assistance to Federal architects, engineers, and energy conservation managers in the form of workshops, seminars, and publications of "How to" manuals. FEMP also operates a clearinghouse on federal shared savings contracting experience for local, state, and federal government.

Federal Laboratory Consortium (FLC)

Gene Stark, Director
Los Alamos National Laboratory
P.O. Box 1663
Los Alamos, New Mexico 87545
(505) 667-4960

The Federal Laboratory Consortium was created in 1974 when the Department of Defense and other federal laboratories were combined. It consists of a network of lab contacts (now Offices of Research and Technology Applications--ORTAs) who are responsible for maintaining a familiarity with their laboratory's expertise and linking this expertise to requests received from outside the laboratories. A user with a problem may typically access the FLC network through the FLC regional coordinator at his/her federal laboratory. The user is then referred by the regional coordinator to the lab with the necessary expertise. The ORTA's knowledge of other labs' areas of expertise depends on the ORTA's experience within the laboratory system as well as informal communication.

One major problem with this reactive technology transfer mode is the lack of knowledge about the FLC-ORTA system, the services it provides, and how to gain access to it. There is also a loss of efficiency due to the separation of passive information services (such as NTIS bibliographic capabilities) from active service provision. Further, the extent of dependence on information networking between FLC members to locate necessary expertise within other labs causes high variability in effectiveness. Finally, the reliance upon lab researchers as key information sources suffers from the fact that the present incentive structure within the labs does not reward researchers who divert attention from an R&D program.

Institutional Conservation Programs Division (ICPD)
Tyler E. Williams, Jr., Director
Office of State and Local Assistance Programs, CE-231
U.S. Department of Energy
1000 Independence Avenue, S.W.
Washington, D.C. 20585
(202) 252-8039

The Institutional Conservation Programs Division administers Title III of the National Energy Conservation Policy Act, which provides matching grants to schools and hospitals to increase the energy efficiency of their buildings. Services currently offered by ICPD include technical assistance analyses and energy conservation measures.

- Technical Assistance Analyses are detailed professional analyses that report the specific costs, energy savings and payback periods obtainable from installation of equipment or physical changes in specific building structures.

- Energy Conservation Measures are retrofit actions that can be taken to conserve energy. Assistance is available to design, purchase and install equipment, or make changes to building structures to reduce energy use. Only schools and hospitals are eligible to receive financial assistance for energy conservation measures. The payback period of eligible measures must be 2 to 10 years.

To be eligible for either of these services, a building must have been constructed prior to April 1977. The majority of program funds are spent on the installation of conservation measures compared with technical analyses.

National Appropriate Technical Assistance Service (NATAS)

Anita Dean DeVine
Technology Applications Division, CE-45
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585
(202) 252-1265

The National Appropriate Technology Assistance Service provides tailored information and technical assistance on appropriate technologies that conserve energy or use renewable energy resources. NATAS is available to anyone in the United States, but users are most often homeowners, small businesses, state and local governments, and institutions.

NATAS emphasizes the delivery of information that is tailored to the specific needs of each user. The NATAS program is organized around four principal tasks:

- Provide capability to disseminate appropriate technology information. This task includes management of the toll-free phone and mail service, management of the NATAS data base access (RECON, DIALOG, etc.) and production of all materials such as publications and reports. This task also includes public information activities such as the design and production of brochures, posters, displays, press releases, special mailings and presentations for meetings.

- Provide tailored information and technical assistance pertaining to engineering and scientific aspects. NATAS provides phone and written responses to clients seeking technical information or technical assistance. On-site assistance is not provided.

- Provide technical assistance pertaining to business planning, patents, licensing and private sector financing. NATAS provides phone, written and some on-site assistance to clients seeking help in business planning and operations.

- Coordinate NATAS with other government agencies and programs. Frequent contact is maintained with State energy offices, DOE Operations/Support Offices, other DOE information services such as CAREIRS, OSTI, NEIC, and other Federal agencies and programs.

NATAS can be contacted by calling the toll-free number above. The telephone service operates from 9:00 am to 6:00 pm Central Time on weekdays; it is not available on weekends or Federal Holidays.

National Energy Information Center (NEIC)
Energy Information Administration
U.S. Department of Energy
1000 Independence Avenue, S.W.
Washington, D.C. 20585
(202) 298-3714

NEIC is the Energy Information Administration's arm for responding to inquiries regarding a wide variety of statistics on all aspects of energy use and production in this country. It provides this information to a broad user community, including representatives of Government and the private sector.

National Energy Software Center (NESC)
U.S. Department of Energy
Argonne National Laboratory
9700 South Cass Ave.
Argonne, IL 60439
(312) 972-7250, FTS 972-7250

Argonne National Laboratory maintains the National Energy Software Center for DOE's Office of Scientific and Technical Information (OSTI). The major objectives of the NESC are:

- to promote the sharing of computer software among agency offices and contractros to eliminate duplication of effort and unnecessary expenditures;
- to facilitate the transfer of computer applications and technology to the information processing community;
- to arrange the exchange of software with other U.S. and foreign agencies and to assist in the acquisition of nongovernment software for DOE offices and cost-type contractors.

NESC collects, packages, maintains, and distributes a library of computer programs, models, systems routines, and data compilations developed by DOE, NRC, and their contractors in carrying out the agencies' research and development activities. The Center checks the library packages for completion and runs test cases to make certain they operate as described. NESC prepares and distributes abstracts describing the software packages in the NESC collection. Finally, NESC communicates with and arranges for exchanges with other U.S. government software centers and foreign computer program libraries and is the focal point for DOE participation in the Federal Software Exchange.

DOE organizations and contractors are responsible for offering unclassified software to the National Energy Software Center along with the necessary documentation. They may provide completed software directly to other DOE organizations and contractors only if the software is also offered to the National Energy Software Center; however, only the National Energy Software Center can provide software to non-DOE and non-DOE contractor requestors.

National Technical Information Service (NTIS)
5285 Port Royal Rd.
Springfield, VA 22161
(202) 377-0365

The National Technical Information Service is a major participant in the development of advanced information products and services for the achievement of U.S. productivity and innovational goals in the 1980's. It is the central source for the public sale of U.S. government-sponsored research, development and engineering reports as well as other analyses prepared by national and local government agencies, their contractors or grantees. The NTIS Bibliographic Data Base is available to individuals through the services of organizations that maintain the data base for public use through contractual relationships with NTIS.

The Center for the Utilization of Federal Technology (CUFT) is the "hard" or "discrete" technology counterpart of the rest of NTIS, and concentrates on the dissemination of information about both patented and unpatented technologies. The NTIS technology subscription service includes information about most of the discrete technologies received by CUFT through agency technologies or Application Assessments. Another subscription service, "Government Inventions for Licensing," includes information about government patents that are available for licensing, marketed by CUFT and other agencies, including DOE.

CUFT also conducts market potential evaluations of some of the patented inventions it manages. This commercial evaluation process consists of two general stages: a quick check of market potential by CUFT staff reduces the patent pool by 80 percent, and a more detailed evaluation by private non-profit research institutes occurs concurrently with test-marketing to a company mailing list. The mailing list of test marketed within particular industries is largely made up of large companies, although it is open to anyone interested in it. Inventions passing the second stage of evaluation are generally kept in the active marketing pool for around five years before being dropped. Approximately 40-50 percent of those patents in the active pool are eventually licensed (Department of Commerce, 1984).

Offices of Research and Technology Applications
(One at each DOE Laboratory)

Section 11 of the Stevenson-Wydler Technology Innovation Act of 1980 requires that each federal laboratory: (1) establish an Office of Research and Technology Applications (ORTA), (2) assign a full-time staff to the ORTA in each laboratory with an annual budget in excess of $20 million, and (3) set aside 0.5 percent of each agency's R&D budget for technology transfer functions. As a result, each of the DOE laboratories through which BCS conducts its R&D programs has an ORTA.

ORTAs are required by this same legislation to perform the following functions:

- assess each R&D project which has potential for use by state and local governments or private industry;
- provide and disseminate information about federally owned or originated products, processes, and services to state and local governments and to private industry;
- provide technical assistance in response to requests by state and local governments;
- cooperate with organizations which link federal R&D resources to potential users in state and local governments and private industry.

Office of Scientific and Technical Information (OSTI)
P.O. Box 62
Oak Ridge, Tennessee 37831
(615) 576-5601

The Office of Scientific and Technical Information in Oak Ridge, Tennessee is the national center for scientific and technical information for DOE. OSTI holdings include not only DOE-originated information but also worldwide literature on scientific and technical advances in the energy field. OSTI maintains three energy-related, computerized data bases which are available to DOE offices and contractors and to other government agencies via RECON, the Office's on-line information retrieval system. Of these three, the Energy Data Base (EDB) is the most comprehensive and includes abstracted references to published literature, journal articles, conference reports, theses, dissertations, and foreign research. The Research-in-Progress (RIP) File describes the new and ongoing energy and energy-related research projects carried out or sponsored by DOE. The non-DOE RIP File contains descriptions of energy research being conducted by other government agencies, domestic organizations, and countries with which OSTI's Technical Information Center (TIC) maintains bilateral exchange agreements.

OSTI prepares periodic compilations of information in specific subject areas upon request by program offices. These publications include Energygrams, illustrated bulletins describing significant advances in technological developments from DOE-sponsored research, and bibliographies of information in specialized areas. In addition, OSTI publishes a bimonthly current awareness bulletin on Building Energy Conservation, containing abstracts of recently published reports.

Argonne National Laboratory also maintains the National Energy Software Center (NESC) for OSTI. This is described in a separate section in this appendix.

Residential Conservation Service (RCS)
Office of State and Local Assistance Programs
U.S. Department of Energy
1000 Independence Avenue, S.W.
Washington, D.C. 20585
(202) 252-1650

This program was established in 1978 by the National Energy Conservation Policy Act. The purpose of the Residential Conservation Service is to identify and encourage installation of cost effective energy conservation and renewable resources in the residential sector. Until recently the RCS Program required large natural gas and electric utilities to inform their residential customers of the benefits of certain energy conservation and renewable resource measures, to offer onsite energy audits of homes, and to offer to arrange for the installation and financing of such measures. The federal budget has been used primarily to review plans from the states for implementing the program, to develop model audit procedures, and to assist states with qualifying additional conservation measures and training auditors. States and utilities select measures that have a simple payback of seven years or less in their climate area and meet DOE established standards.

Small Business Innovation Research (SBIR)
Mrs. Gerry Washington, Program Spokesperson
c/o SBIR Program Manager
U.S. Department of Energy
Washington, D.C. 20545
(301) 353-5867

The Small Business Innovation Research Program was initiated by the National Science Foundation (NSF) in 1977 as an experiment in stimulating the commercialization of innovation by small business. In July 1982, Congress passed the Small Business Innovation Act requiring each agency with an R&D budget in excess of $100,000,000 to set aside a percentage of their extramural budget for small companies. The purposes of the Act are to:

- stimulate technological innovation,
- increase the use of small businesses to meet federal research and development needs, and
- increase private sector commercialization of innovations derived from federal research and development.

Through a sequence of three phases, the SBIR program attempts to apply/modify government sponsored research to meet a need in the marketplace. The first phase is intended to provide seed capital to define and demonstrate the scientific merit and technical feasibility of ideas. Upon successful demonstration of the merit and feasibility in the first phase, a grantee may apply for the second phase grant to further develop the proposed product/process to meet particular program needs and to initiate the commercialization of the technology. Special consideration is given to a proposal able to show capital commitments from nonfederal sources. The third phase is commercialization, utilizing private sector funds and not involving the government. This phase includes securing the financing for introducing the product/process into the marketplace.

Solar Energy and Conservation Bank (SECB)
Richard H. Francis, Head
Room 7110
U.S. Department of Housing and Urban Development
451 Seventh Street, S.W.
Washington, D.C. 20410
(202) 755-7166

Administered by HUD, the bank provides loan subsidies or grants to low- and moderate- income individuals for conservation and solar retrofits. States apply for and work with local financial institutions or other qualifying organizations to distribute funds.

State Energy Conservation Program (SECP)
Office of State and Local Assistance Programs
U.S. Department of Energy
1000 Independence Avenue
Washington, D.C. 20585
(202) 252-2344

The State Energy Conservation Program provides States with the means to establish and implement energy conservation programs for promoting energy efficiency and reducing the rate of growth in energy demand. SECP provides overall coordination, technical assistance, and financial aid to help States successfully implement their programs. In particular, states have been provided with: source books outlining various measures that could be incorporated into a state plan; posters, pamphlets and other energy education materials; training manuals; technical reports; and seminars and workshops. With this assistance a variety of energy programs have been carried out by the States. These include: energy audits for industrial plants not served by other federal audit programs; workshops and seminars on energy conservation and renewable energy technologies and techniques; development and use of energy-efficient procurement practices in state and local government; implementation of thermal and lighting efficiency standards; and the development and maintenance of state energy emergency plans.

Technical Inquiry Service (TIS)
Solar Technical Information Program
Solar Energy Research Institute (SERI)
1617 Cole Boulevard
Golden, Colorado 80401
(303) 231-7303

The Technical Inquiry Service at SERI responds to technical inquiries to specific questions and serves all but the general public. It operates the Solar Technical Information Program (STIP) through which solar and conservation information is provided to the scientific and technical communities. From their files and individual resources from across the nation, TIS provides state-of-the-art information concerning solar energy and conservation information.

<u>University/DOE Laboratory Cooperative Program</u>

Division of University & Industry Programs
Office of Energy Research
U.S. Department of Energy
1000 Independence Avenue, S.W.
Washington, D.C. 20585
(202) 252-6833

The purpose of the University/DOE Laboratory Cooperative Program is to increase the interaction and flow of information between Universities, DOE Laboratories and Energy Technology Centers, to familiarize scientists and engineers with current developments and techniques in energy R&D and maintain a flow of high quality young students into the fields and disciplines critical to energy research and development. The program has a training component and a research participation component.

To support the training of students and faculty, the program sponsors a variety of short-term activities such as topical workshops, institutes or conferences. To increase the involvement of students and faculty in energy research at DOE laboratories, the program supports a variety of internship experiences. Undergraduate students are provided stipends to support summer work at DOE laboratories. Graduate students can participate in a summer program or may be supported to conduct thesis research at a DOE lab. University faculty receive funds to participate in lab R&D programs dealing with subject areas in which they are attempting to gain expertise. This may be accomplished through a summer program, a sabbatical leave program covering 6 to 12 months of research, or a travel program which supports short-term collaboration with laboratory researchers.

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Weatherization Assistance Program (WAP)
Office of State and Local Assistance Programs
U.S. Department of Energy
1000 Independence Avenue, S.W.
Washington, D.C. 20585
(202) 252-2204

This program provides grants to states to install conservation measures in the homes of low-income citizens, particularly the elderly and handicapped. The majority of WAP programs are administered by state agencies and run by non-profit community action agencies which install weatherization measures free of charge to households. Eligible conservation measures include weatherstripping, caulking, storm windows, attic insulation, water heater wraps, thermostat controls, heat exchangers, and heat pump water heaters. Changes in 1984 gave more flexibility in retrofitting multifamily buildings. WAP activities include regional conferences to provide information and training to grantees and subgrantees, and discuss issues affecting the management of the program.

ORNL/CON-202

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