PNL-5607
UC-95d

17

Research Utilization in the Building Industry: Decision Model and Preliminary Assessment

October 1985

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
by Battelle Memorial Institute

Battelle

PNL-5607

PACIFIC NORTHWEST LABORATORY
operated by
BATTELLE
for the
UNITED STATES DEPARTMENT OF ENERGY
under Contract DE-AC06-76RLO 1830

Printed in the United States of America
Available from
National Technical Information Service
United States Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22161

NTIS Price Codes
Microfiche A01

Printed Copy

Pages	Price Codes
001-025	A02
026-050	A03
051-075	A04
076-100	A05
101-125	A06
126-150	A07
151-175	A08
176-200	A09
201-225	A010
226-250	A011
251-275	A012
276-300	A013

PNL-5607
UC-95d

RESEARCH UTILIZATION IN THE BUILDING INDUSTRY: DECISION MODEL AND PRELIMINARY ASSESSMENT

R. L. Watts
D. R. Johnson
S. A. Smith
E. J. Westergard

October 1985

Prepared for
the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Richland, Washington 99352

ACKNOWLEDGMENTS

The progress made in the development of data and models in this report is more the result of the personal contributions of a large number of people than the review and synthesis of written literature. There appears to be little precedent for the models developed.

The direction and initial components of the Research Utilization Program were developed jointly by Oak Ridge National Laboratory (ORNL) and Pacific Northwest Laboratory (PNL) under the sponsorship and guidance of Marvin Gorelick of the Building Systems Division (BSD) of the Office of Buildings and Community Systems (BCS), U.S. Department of Energy (DOE). Thomas Vonier, Energy Committee Chairman for the American Institute of Architects, and Erv Bales, Research Professor of Architecture and Engineering at the New Jersey Institute of Technology, Schools of Architecture and Engineering, supported the steering of this project. This has been a collaborative effort in every sense. Tasks undertaken by both laboratories were designed to contribute synergistically to an overall strategy for managing the interactions between the private and public sector in the area of building energy conservation. This team approach has allowed DOE to draw upon the strengths of both laboratories.

While it is impossible to list the names of everyone who contributed to this report, we will attempt to acknowledge some of those who made substantial contributions to the development of the decision process model:

John Franke, PNL Program Manager of the Research Utilization Program (RU), contributed many helpful concepts and made numerous constructive suggestions during the investigation and preparation of the report.

Marvin Gorelick, DOE Program Manager of the Research Utilization Program, contributed many creative ideas for approaching the modeling of the RU process and encouragement at critical phases of the investigation.

Others who made substantial contributions include:

Tom Vonier of Vonier Associates, Chairman of the AIA Energy Committee
Erv Bales of the New Jersey Institute of Technology (School of Architecture)

Bill Seaton, Manager of Research at ASHRAE
E. J. Soderstrom, M. E. Brown, E. D. Copenhaver, J.H. Sorensen, Oak Ridge National Laboratory
The late Richard Campbell, the late Jim Easterling, Rich Mazzucchi, Stan Pansky, John Stoops, Pacific Northwest Laboratory

The following individuals contributed information used in developing the decision process model:

Blair Abee, Owner Builder Center
Alan Adams, Windowvisions
Rene Adams, Torrant County Builder's Assn.
Tim Barber, Greg Linnerooth, Energy Control Product Division of Minnesota Mining and Manufacturing
Joe Barrows, Bill Pelham, Wood Brothers Homes
Ben Bartolotto, Construction Industry Research Board
Duane Bauger, Probuilt Systems
Jeff Bryson, Sunflake
Ray Champion, Dondi Construction
Enola Dangerfield, Builders Marketplace
Jim Delaplane, Todd Development Company
Ron Downs, Best Built, Inc.
Irvin Eaton, Sandy Snyder, Insoport Industries
Ross Fink, Johnson Controls, Inc.
Liz Fox, Super Insulation Information Service
John Gold, Home & Apt. Assn. Metro Dallas
Jim Greevers, Johnson Controls, Inc.
Bing Hacker, Hacker Homes
Cy Henry, Italix Lighting, Inc.
Bill Huston, Bob Rivinius, CA BIA
O.B. Johnson, O.B. Johnson, Inc.
Joe Kariakin, Novi Development Company
Robert Laris, Laris & Assoc., Inc.
Thomas Lenchek, Balance Associates
Ryan Litchfield, Cascade Energy Homes
Bob Martin, Dividend Development Corporation
John Mephan, Tektronix-Control Service Group
Victor Mirontschuk, EDI Architects/Planners
Bob Moffett, E.I. DuPont de Nemours & Company, Inc.
Ned Nisson, "Energy Design Update"
Louis Novak, Pella Products
Vern Olin, Dow-Ammons Builders
Jim Patton, Durango Owner Builder Center
Art Phillios, Boise Cascade
Howard M. Rider, Blower Door Testing
Lee Rudofsky, Almor Realty
Duane Searles, Colorado Association for Housing and Building
Linda Steinman, Washington State Energy Office
Bob Sterret, Litton Facilities Management System
Bill Streigel, J. E. Dunn Construction Co.
Mike Taggart, Florida Home Builders Association

James Alan Taylor, Daystar Group (Arch/Solar)
Jack Ullrich, Andersen Corporation
Barbara Walker, Unique Homes of Colorado
Vincent Webers, DuPont Division of P&EP

The following individuals contributed extensive time and effort to filling out pro forma model forms:

Robert W. Dowell, General Growth Corporation
Louis J. Lalli, LEHR Associates
Rick A. Martin, Urban Engineering
Stu Haberman
William W. Seaton, ASHRAE

EXECUTIVE SUMMARY AND RECOMMENDATIONS

The Research Utilization Program was conceived as a far-reaching means for managing the interactions of the private sector and the federal research sector as they deal with energy conservation in buildings. The program emphasizes a private-public partnership in planning a research agenda and in applying the results of ongoing and completed research.

The results of this task support the hypothesis that the transfer of R&D results to the buildings industry can be accomplished more efficiently and quickly by a systematic approach to technology transfer. This systematic approach involves targeting decision makers, assessing research and information needs, properly formating information, and then transmitting the information through trusted channels.

PURPOSE

The purpose of this report is to introduce elements of a market-oriented knowledge base, which would be useful to the Building Systems Division, the Office of Buildings and Community Systems and their associated laboratories in managing a private-public research partnership on a rational systematic basis. This report presents conceptual models and data bases that can be used in formulating a technology transfer strategy and in planning technology transfer programs.

SCOPE

This report presents the results of the Feedback and Evaluation Task of the Research Utilization Program. For this task, Pacific Northwest Laboratory examined the structure of the building industry and its practices, particularly the diffusion of knowledge and innovative technology. These topics are not covered exhaustively; however, sufficient information is presented to establish a knowledge base that supports a rational and systematic approach to technology transfer. Other elements of this knowledge base are being addressed by the Oak Ridge National Laboratory.

In this task, a pro forma model of the decision process for planning, designing and constructing buildings was developed. The model was applied on a test basis to a limited portion of the building industry. Also, preliminary investigations have been conducted of the structure of the building industry, the mechanisms available for technology transfer, and the decision environment in which technology is adopted.

In the following sections, the investigations undertaken in the Feedback and Evaluation Task are summarized by chapter.

CHAPTER 2: DECISION PROCESS MODEL

A conceptual model was developed for mapping the interactions of energy conservation opportunities, decision participants and decision criteria. The model places these interactions in the context of the sequence of events occurring in the planning, design, construction and occupancy of a building.

The decision process model provides a structure for locating energy conservation opportunities that occur throughout the phases in a building's life. For particular energy conservation opportunities, the model helps to identify key decision makers so that information can be targeted to the appropriate audience. In addition, the criteria used in making those decisions are identified so that information packages can be tailored to meet the needs of decision makers.

The model is a planning tool for identifying target audiences for information transfer. Because no precedent exists in the literature, the model was created through extensive field investigations. Its structure and format were developed through numerous reviews and modifications by industry, university and laboratory personnel.

Preliminary inferences can be drawn from the results of these field investigations:

- The process of selecting or rejecting an energy-saving technology involves multiple decision makers.

- Many decision participants have effective "veto power" over the adoption or use of a conservation technology.
- The building owner appears to be the single greatest influence on energy efficiency investment.
- Patterns in the process of adopting an energy-saving technology can be identified by modeling the interactions of conservation opportunities, key decision participants and decision criteria.
- Adoption patterns differ for various combinations of building ownership, building use and contracting/construction mode.
- Financial, technical and aesthetic criteria appear to be more important than energy efficiency in building design.

CHAPTER 3: A SEGMENTATION OF THE USERS OF BUILDING ENERGY CONSERVATION RESEARCH

The term "user" refers to firms and individuals who could potentially use the results of energy conservation research in planning, designing, constructing and operating buildings. The user segmentation describes the actual composition of distinct groups of industry decision makers. The segmentation scheme is based on functional business areas (i.e., architecture, engineering, finance, etc.). Data and information are presented on the number of firms, their dollar business volume, their geographic distribution and other parameters for each industry segment.

The segmentation can be used either by itself as a source of market planning information or in conjunction with the decision process model. The major divisions of the segmentation (comprised of industry segments) correspond with the decision participant types identified in the decision process model. Therefore, if the decision process model is used to identify decision participants for a given energy conservation opportunity, the industry segmentation can provide details on the corresponding groups of firms and individuals in the industry who actually make those decisions.

The information on user segmentation is useful in several ways:

- Industry's fragmentation and size can be effectively dealt with by targeting information to well-defined industry segments.
- Industry segments to be targeted can be identified by applying the decision process model.
- Information targeting can be more effective when geographic and demographic factors are overlaid on functional industry segments.

CHAPTER 4: TRANSFER MECHANSIMS AND THE DECISION ENVIRONMENT

In the discussion of the decision environment, factors affecting the choice of mechanisms to be used in technology transfer are described. First, several transfer mechanisms are identified. These mechanisms fall broadly into three categories:

media mechanisms:	mechanisms that provide the means for communicating information through written, audio and/or visual images.
policy mechanisms:	mechanisms that provide incentives for energy conservation through institutional arrangements.
R&D process mechanisms:	mechanisms that facilitate the transfer of information through user involvement in planning, monitoring and evaluating research.

This chapter discusses conditions necessary for information to effectively change decision makers' behavior with regard to technology adoption. It highlights environmental factors that affect the transfer of technology to the private sector. Key points of that discussion include the following:

- Those who first use new technology appear to emphasize noncost-related criteria in their decision process.
- Multiple sources of information tend to re-enforce a new technology's credibility.

- Impersonal transfer mechanisms (written or media) appear to be important in producing the awareness of a new technology.
- Actual adoption of new technology appears to require "people to people" information exchange.
- Credibility of information sources and media appears to be higher for technologies in which little new untested information is transmitted.
- Traditional information sources may be relatively less effective in transmitting information during the early stages of the introduction of new technology.
- Different transfer mechanisms become effective as decision makers progress through stages of increasing awareness and interest.
- Occupants or end users of buildings usually must demand energy conservation measures before decision makers will incorporate them.
- R&D on the reliability of a concept is crucial for its adoption.

RECOMMENDATIONS

The following recommendations result from PNL's examination of the building industry and its practices.

1. The usefulness and validity of the decision process model needs to be assessed beyond the preliminary application described in this report. This assessment could be conducted in a workshop setting with industry practitioners and other experts providing input data required to model additional building types. A workshop would give industry the opportunity to review the model and PNL would be able to observe generalized decision patterns that could help to simplify the model.
2. Effective information targeting will require further development of the user segmentation:
   - A computerized data base of industry firms should be created. The data base should have sort capability on parameters of interest, such as building type specialty, dollar business volume and geographic location.

The data base would be based on the user segmentation and should be constructed to interact with the decison process model and the data base of building industry broker organizations created by ORNL. With this interaction, groups of firms could be targeted individually, directly or through broker organizations. Market penetration could also be tracked, which would allow someone to identify areas where further efforts should be concentrated.

- Concurrently, further research needs to be conducted on each industry segment in three areas: industry leadership, propensity to innovate and business practices relative to the state of the art of building technology. This research would enhance the value and sort capability of the computerized data base, resulting in a powerful tool for identifying target audiences.

  Industry Leadership - Research on building industry leadership would focus on identifying those firms whose practices and specifications are emulated by others in the industry. This research could lead to the most efficient and effective way to demonstrate emerging technologies by working through industry leaders.

  Propensity to Innovate - This research would focus on identifying demographic and other factors indicative of innovative behavior in firms. Knowing these characteristics would help in identifying industry leaders who are most likely to be receptive to adopting innovative technologies.

  State of the Art - This research would characterize each industry segment in terms of firms' practices concerning the state of the art in building technology. This characterization would be presented as a distribution of firms, with firms leading the state of the art on one end and those lagging on the other end. Knowing this distribution in rough quantitative terms would help define the content and format of information that could have the greatest impact in a given industry segment.

4. Transfer mechanisms that affect the R&D process itself--user involvement in research, R&D limited partnerships, industry guidance and review panels,

etc.--should be more fully developed in a topical report. Specific opportunities for their use in the Building Systems Division and the Office of Buildings and Community Systems should be identified.

5. This report provides the first installations of a knowledge base that will improve technology transfer. Further research into technology transfer methods is not specifically covered in the scope of the report, but should be pursued as companion projects.

   - Future technology transfer planning and execution efforts should be technology-specific. A clear definition of the research products available for transfer is required. The creation of an inventory of federally developed design strategies for building energy conservation and tools, components and devices would be invaluable. Each product in this inventory should be characterized in terms of its commercial readiness, market potential and probable adoption. By moving to specifics, the organization and information presented in this report could be better applied and used for planning specific technology transfer activities.

   - A data base of broker organizations in the building industry has been compiled by Oak Ridge National Laboratory (ORNL). This data base and the role of broker organizations in the technology transfer process should be integrated into the material covered in this report. The linkages and interrelationships with industry segments should also be specified.

   - An overall integration of the models and data bases under development by PNL and ORNL should be undertaken. One vehicle for integration might be a menu-driven computer planning tool that would include the models and data bases identified in this report on an interactive basis. Whatever its form, the integration should provide clear planning direction for technology transfer, and it should take advantage of the knowledge embodied in the models and data bases for each technology and technology market.

GLOSSARY

Research Utilization

A private/public partnership based on two way communications to transfer technology that meets the needs of industry and satisfies national objectives.

Building Energy Conservation Decision Process Model

A conceptual model that maps the interactions of decisions related to energy conservation opportunities, the participants involved in making those decisions and the criteria employed in making those decisions. The pattern of interactions changes as a function of three primary drivers: ownership characteristics, occupancy/use type and contracting mode.

Energy Conservation Opportunities

Decision points in the building process that affect the quantity and/or pattern of energy use in a building. These opportunities fall into two broad categories: purely design considerations, and materials/components/equipment selection and specification.

Decision Participants

Individuals responsible for the planning, design, specification, construction and use of a building who have an influence on energy conservation opportunities.

Energy Conservation Technologies

The practical applications of knowledge that provide equal or enhanced end use energy services with reduced energy input. These applications of knowledge can be embodied in materials, components and equipment, or in a design strategy that integrates them.

Industry Segments

Definable groups of organizations related to the building industry that share needs, perspectives and roles in the industry.

Broker Organizations

Organizations that neither directly produce nor use R&D results, but are positioned to leverage the resources of both users and producers by maintaining effective communications links and by maintaining a sensitivity to the needs of both producers and users.

Transfer Mechanisms

Methods, media and devices that potentiate communications and technology transfer. Transfer mechanisms is a general terms that can be disaggregated into media mechanisms, R&D process mechanisms and policy mechanisms.

Media Mechanisms

Transfer mechanisms that provide a channel for written, spoken or visual communications.

R&D Process Mechanisms

Transfer mechanisms that affect modifications to the process of planning and executing research such that direct communication between users and producers of R&D results is enhanced.

Policy Mechanisms

National, state and local political and economic policies that provide incentives to employ advanced conservation technologies.

Information Packages

Discrete arrangements of data and analysis, the content and format of which are consciously designed to meet user needs.

Needs Assessment

A formal activity that results in the precise delineation of the R&D and information needs of users of R&D. Properly done a needs assessment will differentiate the needs of each industry segment in the building industry.

CONTENTS

FIGURES

TABLES

1.0 INTRODUCTION

The Research Utilization Program was created by the Assistant Secretary for Conservation, Buildings Systems Division of the Office of Building Energy Research and Development, U. S. Department of Energy. The purpose of the Research Utilization Program is to promote a systematic approach to technology transfer through encouraging and enabling more frequent and clearer communications between the private and public sectors.

The systematic approach to technology transfer is based on four sets of activities:

- Needs Assessment: Determining the research and information needs of the users of federal building research results.
- Information Development: Transforming raw research results into meaningful information packages for specific audiences.
- Outreach: Inviting industry participation and disseminating packaged research results through appropriate mechanisms.
- Feedback and Evaluation: Providing for industry and peer review of the RU process and its components and events.

These generic activities cannot be carried out in a vacuum. The RU philosophy recognizes that needs differ according to audience or industry subgroup. Therefore, the subgroups in the industry must be defined.

It is also recognized that before energy technologies resulting from federal R&D are adopted, they must be carefully considered by those who plan, design and construct buildings. Therefore, it is important to know how decisions are currently made (e.g., how different building types are chosen), who makes them, and what factors are considered. This can provide insight into the content and format of information to be presented to decision makers.

The issue of outreach is also important. To make intelligent choices, it is necessary to be aware of the options and the environment.

An understanding of decision makers information needs is a prerequisite to an effective, efficient approach to technology transfer. The purpose of this report is to provide a base of information to enhance the effectiveness and efficiency of RU activities. The information in this report is organized the following way:

- Modeling the decision process -- Chapter 2.0 provides information on decision spaces, decision participants, decision criteria, and decision process drivers.
- Defining and characterizing potential users of R&D results -- Chapter 3.0 disaggregates the potential users (the building industry and related institutions) into segments and provides data that characterize these segments, enhancing the ability to tailor information to specific audiences.
- Identifying and characterizing effective transfer mechanisms -- Chapter 4.0 groups and characterizes media channels and other means of technology diffusion so that information can be transferred effectively.

The decision process model described in this report was developed by PNL with the cooperation of many members of the buildings industry. The original version of the model was based on numerous discussions with members of the buildings industry and on an extensive review of the literature. The model was revised a number of times on the basis of feedback from a variety of industry sources. The model was then reviewed by building industry experts at a roundtable conference held in December 1984 and sponsored by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers. Roundtable participants included designers, architects, developers, contractors, trade associations, trade publishers, manufacturers, building code officials and government officials. Based on this review, revisions were made to the decision model. It is anticipated that further revisions and refinements will be made to this model as it is reviewed by other members of the buildings industry.

Primary information was gathered to help verify the dimensions chosen for the decision process model. This information was collected through a series of telephone contacts with buildings industry members including architects, builders, building associations, and building component manufacturers. A portion of the results of this information collection effort is included in Section 3.6.

The segmentation of the buildings industry and the characterization of industry segments were developed using the open literature. This first level of development has shown that the buildings industry, while large and complex, is understandable. The next level of development would provide further detail on each industry segment, preferably at the firm level, so that outreach efforts may be directed toward the portion of the industry segment representing the greatest business volume.

A myriad of barriers impede or prevent the transfer of many technologies from the laboratory to the commercial market, and a variety of these barriers are encountered in the buildings industry. The Energy Division of Oak Ridge National Laboratory has prepared an excellent report (ORNL/TM-9630) highlighting these barriers that have slowed the introduction of energy-conserving technologies. The Oak Ridge report also presents detailed information on the role and strategy of the Research Utilization program by highlighting DOE's current technology transfer activities for the buildings industry.

2.0 THE DECISION PROCESS MODEL

The RU program focuses on the conservation opportunities realistically available to those who own, design, construct or occupy commercial and residential buildings. A large number of complex decisions and actions by interacting participants determine the energy efficiency of commercial and residential buildings. The motives and interests of these participants vary. Some opportunities may not be exploited because of institutional difficulties. Others may be foregone because those who make the critical decisions either lack complete, reliable information or because they do not believe the information they receive. RU focuses on this latter class of opportunities to improve the energy efficiency of the buildings while maintaining/improving the quality of services received by those who work and live in them.

This chapter describes three key dimensions of the decision opportunities available to conserve building energy. This chapter also describes the conditions of ownership, occupancy/use, and construction/contracting mode, which have great impact on the relative importance of the three key dimensions. Those factors that affect the relative importance of the three key dimensions are called "decision process drivers" in this report.

The three key dimensions of the decision opportunities are:

- Decision Spaces - When and where do energy saving decision opportunities occur during the life (conception, construction, use, and demolition) of a building?
- Decision Participants - Who actually makes the decisions (or participates in the decisions) at various stages of a building's life?
- Decision Criteria - What factors control and influence decision making?

The dimensions of the decision process are shown in Figure 2.1. These dimensions are discussed in more detail in the rest of the chapter, along with the process drivers which affect the relative importance of the dimensions of the decision model.

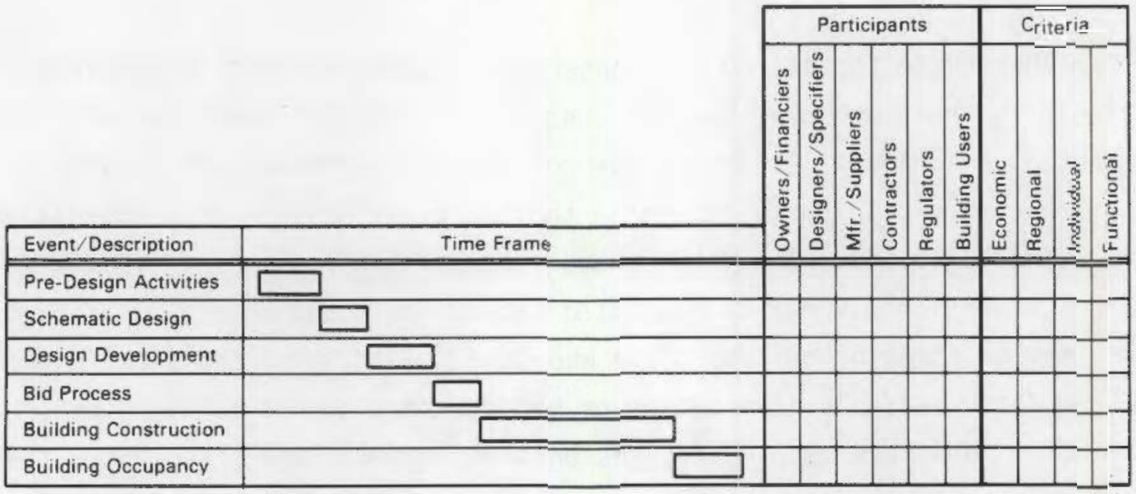

FIGURE 2.1. Decision Process Model of Energy Conservation

2.1 DECISION SPACE

Energy decision opportunities occur throughout the useful life of a building, from the predesign phase into its occupancy/use phase, as shown in Figure 2.2. Knowing when the opportunities are available can help in the development, preparation and targeting of R&D results into useful information packages. The decision space, or the period of time in which a given energy conservation decision can be made, opens and closes during the building life cycle. Reconstruction or adaptive reuse presents opportunities somewhat similar to those encountered in new construction (Figure 2.2).

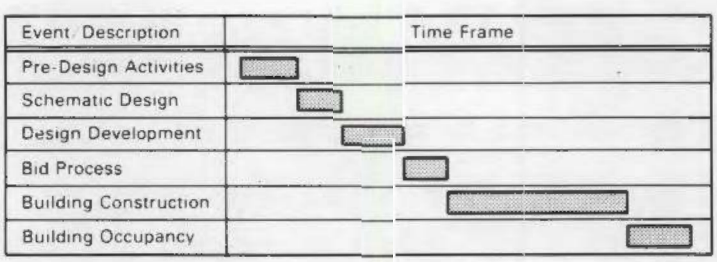

FIGURE 2.2. Decision Space Energy Opportunities

Great opportunities for improving the energy efficiency of buildings occur in the design phase since nothing has been constructed, and since system components can be integrated at the highest overall level of efficiency. Materials and labor savings, plus projected operating cost savings can offset, or at least may reduce, the higher initial costs that often accompany energy saving technologies. The level of individual preference and the desired aesthetics relevant to the occupancy/use of a building can also be optimized at these early phases.

From our discussions with industry we estimate that up to one-third of energy conservation equipment specifications are modified in the bid and construction process. Even if energy conserving features are fully implemented in bidding and construction, there are ample opportunities to misuse them or fail to maintain them in later phases of building use. Energy conservation opportunities may occur as a result of normal building remodeling.

The following outline displays the phases of a building's life and includes some examples of energy saving opportunities. The outline may imply that there is a straightforward sequence of phases in a building's life. In reality, this is frequently not the case. Many buildings skip phases, some buildings repeat phases, and phases frequently overlap. This outline does provide a framework for recognizing and characterizing the types of energy saving opportunities that are available.

Phase	Energy Saving Opportunities
Predesign	Site selection, building orientation and feasibility studies, selection of building massing and fenestration schemes
Schematic Design	Preliminary floor layout, building shape and glass area
Design Development	Lighting, plumbing and HVAC designs, selection of "R" values
Bid Process	Acceptance or rejection of substitutions, alternatives, performance specifications and standards.

Building Construction	Use of substitutions to meet critical schedules and to substitute for unattainable items.
Building Occupancy	Appliance selection and placement - appliance loads now exceed lighting in many offices; use of controls such as occupant sensors.
Adaptive Reuse/ Reconstruction[a]	Many of the decision opportunities listed above are available; however, it may not be as efficient to utilize energy conservation technologies at this stage as it would be at original design and construction. However, unforeseen opportunities may arise ad hoc.
Demolition (an alternative to reuse)	Recycling or scrapping of components/materials.

Each of the building phases listed above has a number of associated subphases or activities. These activities may be carried out explicitly or they may be combined with others. The major decision opportunities for improving the energy efficiency of buildings are embedded within these subphases and/or activities grouped below according to building phase.

2.1.1 Predesign Phase

Major energy saving decisions in the predesign phase include:

- Deciding on the location
- Deciding on the size
- Developing the building program
- Deciding on the amenity levels to be provided
- Deciding on the level of financial commitment.

The predesign activities (during which these key decision points are encountered) are provided below:

(a) Adaptive Reuse and Demolition are omitted from Figures 2.1 and 2.2 for simplicity; however, both phases do provide opportunities.

Data coordination: the gathering of site data, climatological data, tax information, code and zoning information, etc., for the site and its alternatives.

Market studies (where applicable): the gathering and assessment of demographic and other land use factors necessary to determine whether sufficient demand will exist for the services the proposed building can supply.

Building programming: the development of a comprehensive description of the functions, amenity levels, aesthetic requirements, and special needs of the principal/client, including flow diagrams of product/personnel.

Facilities surveys: the assessment of the availability of sewer, water, electrical power, rail sidings, and shipping services, if required.

Feasibility studies: the comparison of a client's needs (from the building program) with the site data and facilities surveys to determine whether the site and facilities meet the client's requirements.

Budgeting process: the development of rough cost estimates and cash flow requirements for energy conservation technologies and a finance availability assessment so that a decision can be made by the principal on the advisability of moving to the next phase the preparation of the schematic design.

2.1.2 Schematic Design Phase

Major energy saving opportunities in the Schematic Design Phase are related to:

- External appearance: building orientation and shape, surface material, window to wall ratio, external shading, massing
- Building layout: HVAC space and thermal mass, floor to floor height, ceiling type, conveyances, illumination/daylighting, space allocation.

These energy saving opportunities arise in the following schematic design activities:

Building program review: The building program will be reviewed and revised taking into account the results of the studies of market potential, feasibility, and the budgeting process.

Finalization and approval of the building program: The building program is revised several times before it is finalized and approved by the client.

Development of a model/elevation drawing: The decisions that affect the exterior appearance frequently have a very large impact on energy efficiency of the building. Some of these decisions include setback, orientation, surface to volume ratio, window to wall area ratio and location, exterior shading, and floor to floor height.

Development of floor layouts and outline specifications: This step is to let the client know what use can be made of the building - how many tenants can be accommodated, as well as the amenity level that may be provided.

Client review and approval: At this step, knowledgeable clients can ask for, and economically obtain, changes that will improve the energy efficiency and lower the operating costs of the building. Sometimes this opportunity is missed because other criteria are of greater concern at the time.

2.1.3 Design Development Phase

Major energy saving opportunities in the design development phase include:

- Internal appearance: windows/blinds, doors, wall finishes
- Illumination level/lighting efficiency: daylighting controls, fixture selection and location
- HVAC system: zoning, sizing of cooling and heating systems, air quality standards, variable speed fans, selection of heating and cooling system equipment, integrated or separate controls, overall integration with daylighting and lighting levels
- Plumbing: pipe sizes, insulation, waste heat recovery, recirculation systems or dead-ended systems

- Electrical systems: operating voltages, power factors, appliance loads, bus layouts, control scheme for lights
- Conveyances: number and placement
- Shell/envelope: structural details, specification
- Thermal resistance values specified for walls, windows, doors, etc.
- Selection of energy sources, fuel types.

These energy saving opportunities arise in the following design development activities:

Architectural drawings and specifications: floor plans, window and door details, and finish specifications

Structural design: footings and foundations as well as beams, columns, stringers, and other structural details

Mechanical design and specifications and equipment selection: designs and specifications for heating and ventilation, plumbing, and escalators/elevators

Electrical design and specifications: location drawings showing outlets and fixtures and control devices such as thermostats and microprocessors for management/operating control systems, and the coordination of illumination with daylighting

Budget review and approval: budget review and approval by the client/sponsor. In this phase the natural tension between capital investment and long-term efficiency of the building is most evident. This tension is often the overriding factor in decisions affecting the energy efficiency of the building.

2.1.4 Bid Process Phase

The bid process phase includes the preparation of detail drawings and specifications as well as those activities involved in letting the contracts. Major energy saving opportunities in the bid process phase include:

- Preparing budgets, bid packages, detail drawings and specifications and advertisements that include energy savings features

- Evaluating proposals/selecting contractors who understand energy conservation
- Negotiating substitutions/modifying specifications/finalizing contracts.

Thus, energy saving opportunities arise in the following bid process activities:

Preparation of detail drawings and specifications: These are sometimes neglected or incompletely prepared. Such omissions can result in expensive change orders/litigation.

Budget review and approval by the client: Frequently the detailing process reveals potential costs that were not previously evident.

Preparation of bid packages: Adequate care results in lower bids from competent contractors/subcontractors, acquiring energy efficient levels within competitive bidding.

Advertisement: Allowing adequate time for response is important. If the time for response is short, it is regarded as a strong signal that the contract process is merely a formality; the ethics of such a practice may be suspect.

Proposal evaluation: This process is made easier if sufficient care is used in the preparation of the bid package. Many unacceptable contractors will not bid if adequate information is supplied. The net result can be that fewer inappropriate or ill-prepared bids are received.

Contractor selection: Contractor selection is very important to energy efficient building construction. The experienced, energy-committed contractor has greater finesse and expertise in employing the necessary techniques and materials, integrating them to produce the desired performance levels in an energy efficient structure. For example, less difficulty will be encountered in achieving low infiltration rates and effective vapor barrier installation if a contractor has had experience with technologies that produce these results.

Negotiation process and modification of specifications: The best contractor for the job frequently will bid alternatives or will not propose to meet all of the requirements. It is in this phase that many energy efficient concepts are lost because someone bids lower cost alternatives, and the alternates are accepted by the client. On the other hand, contractors experienced in construction of energy efficient buildings may be able to offer very attractive alternatives with the potential of improving the efficiency of the building. This stage of contract negotiation should be viewed as an opportunity.

Budget review and approval (by client) and contract award: This step completes the bid process phase.

2.1.5 Building Construction Phase

There are many opportunities to improve the energy efficiency during building construction or, on the other hand, to lose some of the expected benefits specified during earlier phases of the building process. These opportunities are listed below:

- Structural installation methods
  - Insulation
  - Air/vapor barriers
  - Door and window systems
- HVAC installation techniques
- HVAC balancing
- Plumbing installation techniques
- Electrical system installation techniques
- Systems performance verification
- Conveyance installation and control adjustment
- Inspection/compliance
- Modifications for compliance.

These energy saving/loss opportunities arise during:

Materials procurement: This is the first activity in which plans and preferences meet reality. If the specified energy saving equipment/materials involve delivery schedules that will delay the completion of the project, they probably will not be used. Delays increase costs through impacts on working capital, increases in labor and supervision costs, and lost income from rentals.

Site preparation, excavation, and installation of foundations and footings: These activities are often thought of as relatively energy neutral, although below-grade heat losses are likely to be taken more seriously as other sources of losses are successfully eliminated and as data on the magnitude of the below-grade losses accumulate and are disseminated.

Above-grade structure and shell construction: This activity offers considerable challenge to actually achieve desired levels of insulation and air/vaoor permeability control.

Mechanical and plumbing systems installation: These activities are not usually thought of as having serious energy impact; however, the hot water and steam lines can be large energy losers depending on routing, layout, and insulation effectiveness.

Electrical wiring, fixtures and equipment installation: These building systems have widely differing efficiences, and proper zoning can allow for turning off lights when they are not needed.

Conveyance installation and adjustment: Conveyances can be selected so that they operate at very low capacity, or so that part of the equipment can be idled during slow periods allowing for greater energy efficiency of the remainder.

Inspection: These activities, performed by city, county, and state, can insure that institutional provisions are met. However, most of the code requirements relate to health or zoning issues rather than to energy efficiency.

In summary, the contractor can significantly affect the implementation of energy saving concepts desired by the owner. The advice given by the contractor during the design, procurement and construction phases is weighed heavily by all participants.

2.1.6 Building Occupancy Phase

Major energy saving opportunities in the building occupancy phase include:

- Thorough inspection and testing by the owner
- Acceptance of the building only after performance is verified
- Operations and maintenance procedures prolonging the useful life of energy saving equipment and the integrity of the structure.

These energy saving opportunities arise in the following building occupancy activities:

Inspection and testing by the owner: The inspections by the various building officials will not necessarily protect all the interests of the owner. The building officials are oriented (properly so) toward protecting public welfare. Tests and inspections beyond those performed by these officials are likely to be particularly important to the energy performance of the building. For example, the building may be completed at a time of the year in which there is little stress on the HVAC systems. Since the HVAC load is dependent on the use of equipment by its future occupants, the owner should test these systems fully. It is quite difficult to measure vapor permeability to give another example of difficulties of testing.

Acceptance by the owner: The use of energy conserving measures may be limited if they delay occupancy. The owner is usually anxious to move into the new residence or to have tenants move in.

Depreciation and maintenance: All equipment and facilities begin to depreciate at the moment the building is completed. Physical and legal depreciation are, of course, quite different, although they are both irreversible and may temporarily coincide for a specific building. A properly designed maintenance program can slow the degradation of the building and its equipment. Even the best energy conservation equipment can become inefficient if it is not maintained properly.

Leasing and subleasing: The motivations of a tenant are frequently different than those of the landlord. The relationship between the two can be quite complex and may not necessarily provide much incentive/opportunity for energy conservation.

Modification of partitions and finishes: In large buildings this is a more-or-less continuous process because facility needs change with changes in personnel and with the changing nature of the business. Energy conservation concepts which do not accommodate these changes will not find widespread application. Unfortunately, originally high standards of building performance can quickly disappear during building modification.

Recycling of leasing and modification steps: This process offers many opportunities for expediency, and building performance frequently suffers as the building ages and tenants come and go.

2.1.7 Adaptive Reuse/Reconstruction Phase

Adaptive reuse is being revived and involves most of the steps previously discussed in the above phases, which were illustrated in Figure 2.2. Many of the energy saving opportunities available in new construction are unavailable or are made difficult during adaptive reuse or reconstruction. Further investigation of the opportunities of this growing field is needed.

2.1.8 Demolition Phase

Demolition offers few opportunities for energy conservation, although the decision to tear down a structure has enormous energy implications. The intrinsic energy incorporated in materials can be recovered if they can be reused; as materials become more precious, it will become more popular to reuse them. Also, there is an increasingly lucrative nostalgia market for used windows, doors, and fixtures. Unfortunately, some of these antiques are very energy inefficient. Demolition sometimes offers greater opportunity for energy conservation than attempting to retrofit the existing building (adaptive reuse/ reconstruction).

2.2. DECISION PARTICIPANTS

The decision to use or to defer energy efficient concepts involves or affects a number of participants: 1) legal owners/financiers, 2) designers/ specifiers, 3) manufacturers/suppliers, 4) contractors, 5) regulators, and 6) building users. It is possible for these categories to include only one individual or one organization, and decisions frequently involve more than one of the categories of participants, listed in Figure 2.3. Thus, the decision process model shows the influence of decision participants on the energy decisions throughout the phases of the building process.

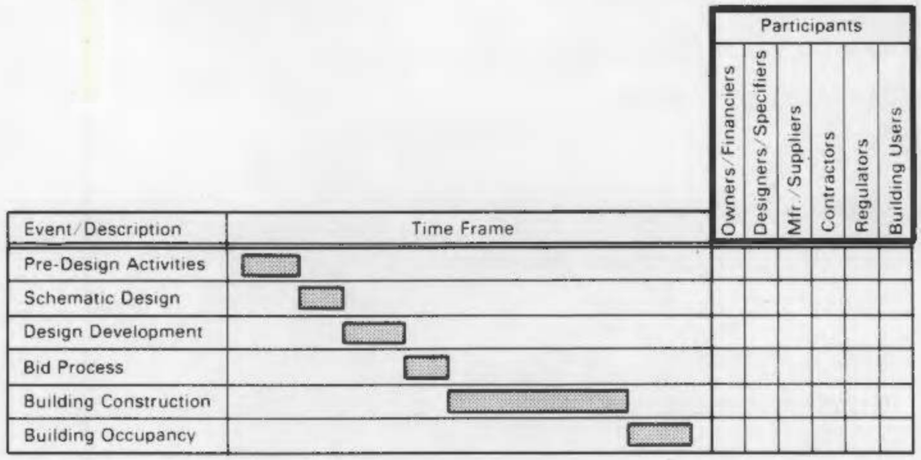

FIGURE 2.3 Groups Participating in Decisions

Decisions in each phase of a building's life are actually shared by many different individuals for a variety of reasons. Some participants are chosen because they have specialized knowledge of the technical area involved. The project may be large enough to make it practical to subdivide it into tasks. The decision may be perceived to be too unimportant for the principal or chief architect. Sharing or delegation of decision making is very common and adds complexity to the task of identifying the key decision makers for a given technical advance.

The list of energy conservation decision participants used in this report is divided into six basic categories, with each category representing several participating interests:

- OWNERS/FINANCIERS
  - Owner/property manager
  - Developer
  - Real estate broker
  - Lending institution
- DESIGNERS/SPECIFIERS
  - Architect
  - Mechanical engineer

- Structural engineer
- Electrical engineer
- Energy engineer
- Illumination consultant

- MANUFACTURERS/SUPPLIERS
  - Manufacturer/processor
  - Distributor/dealer

- CONTRACTORS
  - General contractor
  - Construction/project manager
  - Electrical contractor
  - HVAC contractor
  - Plumbing contractor
  - Roofing contractor
  - Conveyance contractor
  - Specialty contractor (including all other subcontractor participants)

- REGULATORS
  - Zoning agency
  - Inspectors of all levels: local, state, and federal energy commission enforcers

- BUILDING USERS
  - Occupant/lessee
  - Energy manager
  - Building/maintenance manager

The participants in the decision process become involved in one of several ways: 1) they initiate the request or requirement and approve subsequent modifications, 2) they consult, providing recommendations/information about the energy conservation concept, 3) they specify the energy conservation concept on the drawings or in the specifications, and 4) they construct the building, purchasing and installing the materials and equipment.

These participants have different needs and viewpoints which influence the way they relate to a new energy saving technology. Owners intending to rent out the space after completion may be far more concerned with the initial cost of energy saving technology than with the utility bills if the terms of the rental agreement call for renters to pay for the utilities. Financing entities are always concerned with the potential resale value if they have to foreclose. They may see new energy saving technologies as negative factors in resale if they escalate initial cost. Architects are concerned with their professional reputation and will have to weigh this factor against the probable effect of a specific project. Similarly, consultants on the project are concerned with the risk to their reputations from advising the use of a new technology.

The contractors will also be concerned with controlling and minimizing construction costs. Any delays or difficulties encountered with new technology will inevitably increase costs and usually will reduce profits. Profits to builders are highly sensitive to the overall length of the construction period due to the working capital they have tied up. If new technology adds to the length of that schedule, contractors will do everything they can to eliminate it, or they will increase their charges accordingly.

Participant concerns are included in the decision process model and are referred to as decision criteria. Research utilization may be accomplished more quickly if the concerns of participants in the decision process are met by the media and mechanisms employed.

2.3. DECISION CRITERIA

The decision criteria used by individuals and organizations involved in the building industry are divided into four classes: economic, functional, regional and individual (see Figure 2.4). Each decision participant has several criteria which control and influence energy conservation decision making.

A system was established for classifying each criterion as minor, significant, or major:

Minor - Indicates that the criterion is considered but is not of primary importance under the identified conditions of ownership-occupancy/use-construction.

Significant - Indicates that this criterion is important to the decision maker(s).

Major - Indicates that this criterion is important to the decision maker(s).

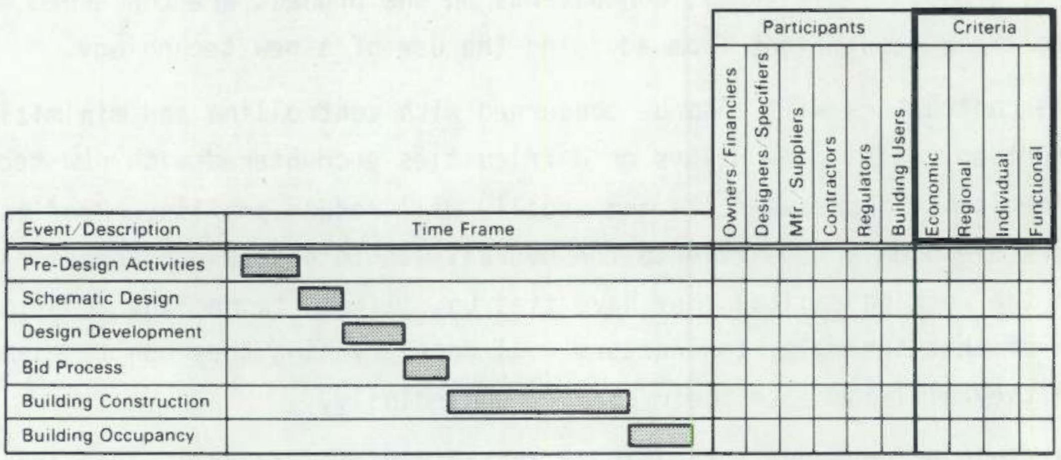

FIGURE 2.4 Classes of Decision Criteria

The criteria for energy decisions are:

- ECONOMIC
  - Initial cost
  - Payback/return on investment
  - Life cycle cost
  - Operating cost
  - Sale/resale potential
  - Lease potential
- FUNCTIONAL
  - Ease of installation
  - Ease of maintenance
  - Ease of operation
  - Durability/reliability

- Flexibility
- Safety/health
- Modularity: maintenance/expansion
- Systems compatibility

- REGIONAL
  - Climatic/geographic appropriateness
  - Compliance (codes/standards)
  - Style/trend
  - Availability

- INDIVIDUAL
  - Preference
  - Professional reputation
  - Aesthetics

Uncertainty in the information available to assess these criteria affects the impact of each of the criteria above. Brief descriptions of the manner in which the criteria may be involved in the interactions of an energy conservation decision follow.

Initial cost: Many of the participants are concerned about the initial capital cost of using an energy conserving technology. The owner/resident may choose one technology over another based on relative initial capital costs. These costs include the initial capital outlay as well as any associated tax credits.

Cost effectiveness: Many participants decide to use energy-conserving rather than conventional technologies based on a comparison of their energy saving potentials. Several analytical techniques are available for making this comparison, ranging from simple payback analysis to the more sophisticated life cycle cost analysis including productivity impacts.

Operating costs: A participant may be primarily concerned with the cost of operating a device or system (e.g., costs reflected in monthly utility bills).

Resale potential: The financing institutions and the builders are concerned with building marketability. If the structure has some unique features, the future market for the building may be narrow.

Lease potential: The parameters of the market audience.

Ease of installation: In some cases the least expensive device to purchase may in fact be the most expensive to install. The device may require structural changes that would delay the construction schedule, or it may require specially trained individuals to install it.

Ease of maintenance: A system should require minimum maintenance; lengthy maintenance downtime is very undesirable. Additional maintenance-related costs are valid considerations.

Ease of operation: A system must be easy to operate and require a minimal skill, or it will probably not be adopted.

Durability/reliability: Building systems must be able to operate effectively through a broad range of building loads. Only those systems that can operate effectively and that are serviceable and durable will be used. The type or brand name of the device must carry with it the sense of dependability and trust.

Flexibility: The ease with which change is introduced (such as office construction) allows the needs of a variety of clients to be met.

Safety/health: To minimize a building owner's liability, a device or system must not be a fire hazard or otherwise dangerous to the building occupants.

Modularity: The selection of a technology may be based on being able to expand the size of the system with the size or use of the building. For instance, photovoltaic modules can be added in small increments as a building's energy consumption increases over time. Another consideration is modular capability to reduce maintenance downtime.

Systems compatability: If a desired or requested system is not compatible with interacting systems, it may not be effective and functionally efficient.

Climate: Several climatic factors in the preparation and design of a building depend upon geographic location.

Compliance (codes and standards): The decision to use or to reject an energy technology will be based upon compliance with local, state, or federal restrictions, along with other considerations.

Style/trends: Styles/trends in buildings and building technology vary from region to region.

Availability: The system or device must be readily available from a reliable distributor. Any delay in receiving the device will cause delays in building completion.

Preference: Individual requirements and choice.

Professional reputation: A system with a known name or one that has been frequently used in the past is often preferred over a new, unknown system. Decisions to use a new technology that differs from the status quo are made by owners, designers, or builders. Often, these decisions are made with some degree of professional risk. Thus, judgment plus task performance is essential.

Aesthetics: An item may be chosen based solely on its attractiveness. For example, a specially designed window may have more eye appeal than a conventional window.

It is important to understand that not all of these criteria are relevant in every phase of a building's life, nor are they of equal importance to every decision participant. The significance of a criterion depends upon both 1) the person or persons responsible during any given phase in a building's life and 2) the combinations of ownership, occupancy/use, and contracting/construction mode (i.e., "decision process drivers"). These process drivers are important in designing technology transfer initiatives.

2.4 DECISION PROCESS DRIVERS

Decision opportunities appear to follow patterns that vary with building ownership, occupancy/use and contracting mode. These parameters, called decision process drivers, may affect the selection of RU strategies. These drivers were identified during industry discussions.

From our database and the direct feedback from the industry, it appears that as the process drivers change, so do the energy decisions. The important decision process drivers are provided below. Verifying these as the definitive categories of process drivers is outside the scope of this investigation.

2.4.1 Ownership Mode

The classes of ownership most frequently described include:

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

Different patterns of ownership (see Figure 2.5) result in different degrees of participation in energy decisions, and in changes in the negative importance of the decision criteria. This suggests that research results might be packaged differently for different owners. Different ownership patterns influence a decision maker's effectiveness.

2.4.2 Building Occupancy/Use Mode

Building occupancy/use patterns can be categorized broadly into three groups: residential, commercial, and institutional.

- RESIDENTIAL

  single family
  multifamily, low rise
  multifamily, high rise

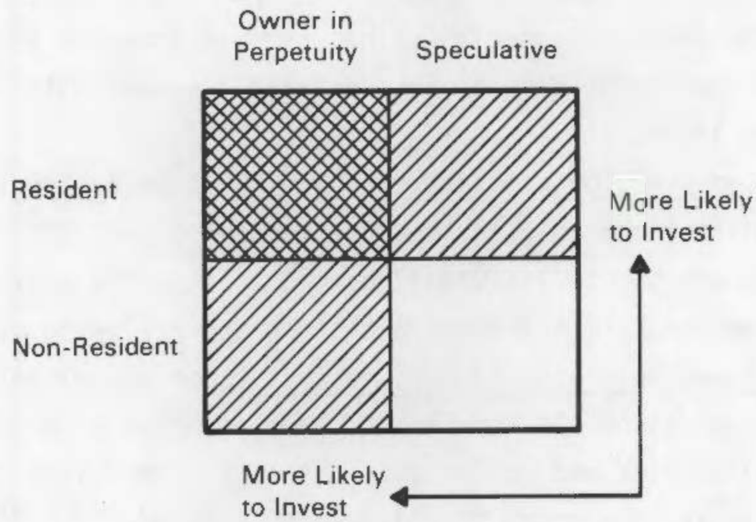

FIGURE 2.5 Ownership Patterns

- COMMERCIAL
  - Business, small office and light commercial
  - Business, large office
  - Recreational facilities
  - Warehouse, storage
  - Retail store, mall, shopping center
- INSTITUTIONAL
  - Federal, state, county, city
  - Religious and charitable foundations
  - Hospitals and nursing homes.

Occupancy/use modes dramatically affect both the effectiveness of the decision participants and the key criteria used in making decisions.

2.4.3 Construction Contract Mode

The construction contract mode falls into four groups: design-bid-build, design-build, negotiated construction, and fast track/multi-bid package.

- Design-bid-build is a straightforward process in which the design activities are initially set forth, a bid process is followed, and then the building is constructed by the successful bidder.

- Design-build is increasingly common: this mode eliminates a separate bid process. The owner is usually further removed from the key energy conservation decisions because the contract includes both design and the construction tasks.
- Negotiated construction contract can have the same design activities as others but differs greatly in the construction phase. Various parts of the construction are let to individual contractors on the basis of past experience or reputation without accepting and reviewing multiple bids.
- Fast-tracked and multiple-bid package jobs (such as multiple sequential construction of eight-plex apartments or franchised food outlets) introduce several complexities and variations. It is possible that pre-engineered systems, such as in a metal building, are designed and built with no knowledge of what mechanical systems are to be employed after the purchase and erection of the shell. However, the factory built, precut home or office building may be completely designed and fabricated and may also be supplied with appliances and finishes so that all systems are integrated and coordinated for on-site construction. There are a number of variations of fast-tracked construction and contracting modes.

These modes can represent many of the variations in designing and contracting building construction typically encountered. The importance of establishing the drivers which pertain to any building is that for a specific decision process, the targeting of an audience and the selection of a mechanism for technology transfer hinge upon the particular modes of ownership, occupancy and construction involved.

2.5 DECISION MATRIX

In the previous sections, dimensions of the decision process model have been presented. A convenient way of displaying and summarizing the interaction of these dimensions is the decision matrix (Figure 2.6).

The vertical axis of the matrix lists the building phases from predesign through building occupancy. The horizontal axis is a time line that represents the timing and duration of each building phase. Next, the various participants in the decision process are listed, followed by the criteria they consider. A separate decision matrix is completed for each combination of decision drivers (i.e., ownership, occupancy and contracting media).

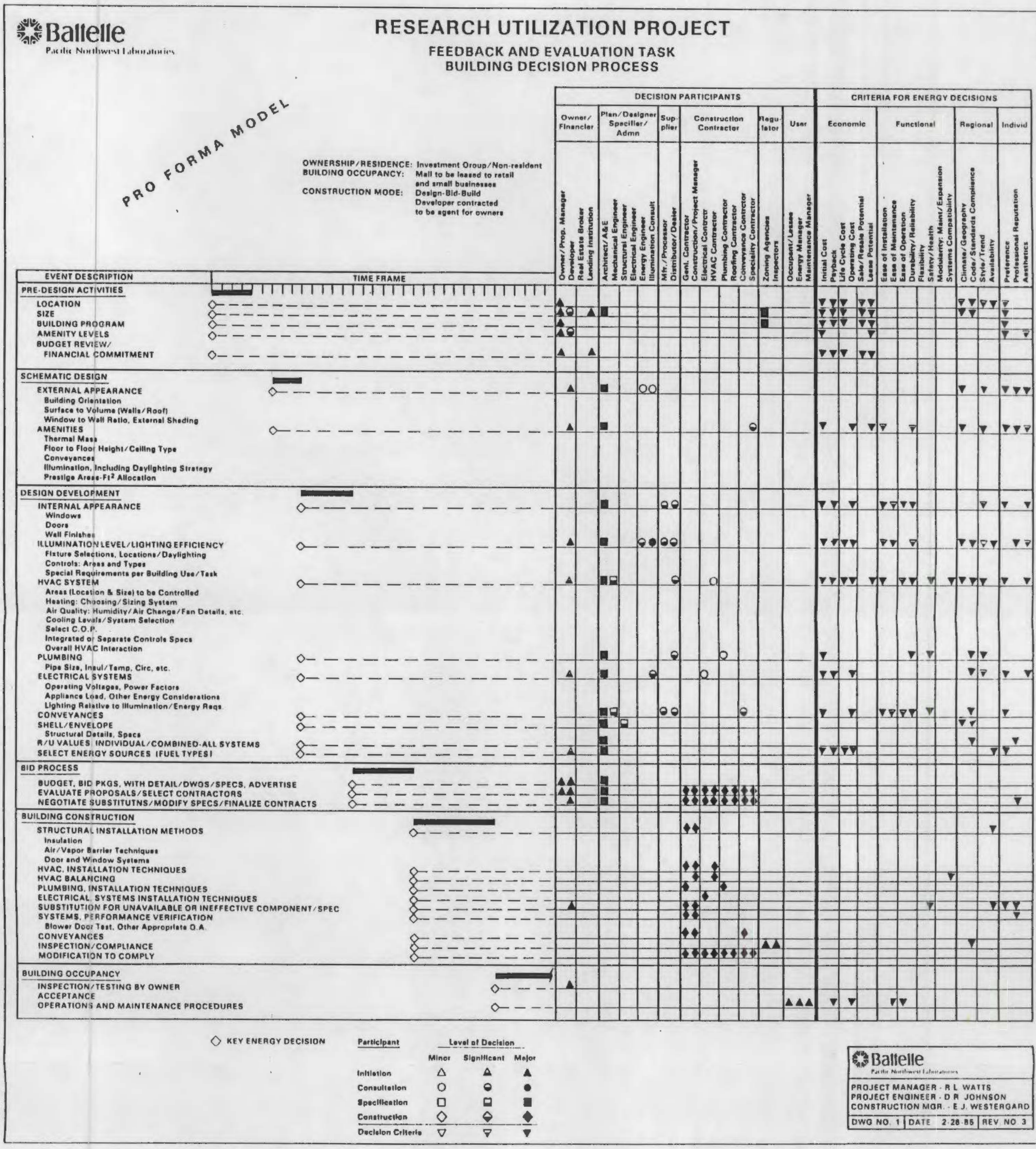

FIGURE 2.6. Example of a Completed Decision Matrix

The involvement of a participant in an energy-saving decision is indicated by four symbols ▲, ●, ■, ◆, representing an initiator, a consultant, a specifier or a contractor. The level of the participant's involvement is indicated by the symbol's shading. The criteria considered by a participant are indicated by a single symbol, ▼, and the level of importance is indicated by the level of symbol shading.

The decision matrix example presented in Figure 2.6 is for the following decision process drivers:

- Ownership/residence: Investment group/nonresident
- Building occupancy: Mall to lease for retail and small business
- Contract mode: Design-bid-build.

This matrix displays the major participants involved in the decision to adopt or to reject energy-saving technologies for this building. Information used to develop this matrix was gathered from contacts with various members of the buildings industry. Other combinations of process drivers need to be examined in future work.

The information displayed is interpreted by first selecting a building event and activity, such as Schematic Design and External Appearance. Reading across the page, the participants are identified first. For this activity, the developer initiates the decision to use an energy-saving technology, as indicated by a ▲. The architect/engineer is also involved in an energy-saving decision during this activity, but as a specifier (as indicated by a ■). The energy engineer and the illumination consultant play minor roles during this activity, participating as consultants (as indicated by a ○).

The major criteria that these participants consider in deciding whether to use or reject an energy-saving technology during this building activity are climate/geography, style/trend, preference, professional reputation, and aesthetics (as indicated by a ▼).

This chapter presents a structured model and indicates a methodology to help develop targeted RU programs with the potential of speeding up the diffusion of key technology to those who own, design, build, and occupy residential and commercial buildings.

2.6 A COMPLETED DECISION MATRIX

While developing the decision process model for the building industry, it was assumed that the decision process was quite complex, that the number of participants varied from phase to phase, and that the criteria considered by participants were a function of the process drivers. To test this hypothesis, data were gathered from the buildings industry, and several decision matrices were completed. These data were collected through conversation with industry personnel. The data collected tended to confirm that the assumptions we had made were correct. However, some results indicated that some of the decision matrices were completed incorrectly.

When we sorted out the definitional problems, we still retained considerable information, which is displayed on the simplified decision matrices that follow. Examples of the results are presented in Figures 2.7 and 2.8. The decision process drivers chosen for this example were:

- Ownership: corporation of professionals
- Occupancy: small office/residence
- Construction mode: design-bid-build.

For simplicity, only two types of participants are noted in these matrices: the initiators are indicated by stars, and all other participants are indicated by vertical bars. The importance of non-initiating participants is noted by the height of the bar, with taller bars signifying greater influence in decisions. An empty cell means that none of the individuals surveyed felt that a given participant was involved in making an energy saving decision during a particular building phase. The nomenclature that was previously presented identified a participant as an initiator, a consultant, a specifier or a constructor. This may yet be the preferred method for classifying the participation of individuals. However, we believe that the best method for gathering this type of data would be in a workshop setting with building industry members. In such a setting, the questions regarding the proper procedure for completing the decision matrix could be answered.

The criteria used by these participants are also represented by vertical bars. Again, the importance of a criterion is designated by the height of the bar. Empty cells indicate that none of the respondents listed that particular criterion as being considered by any participant for the given building phase.

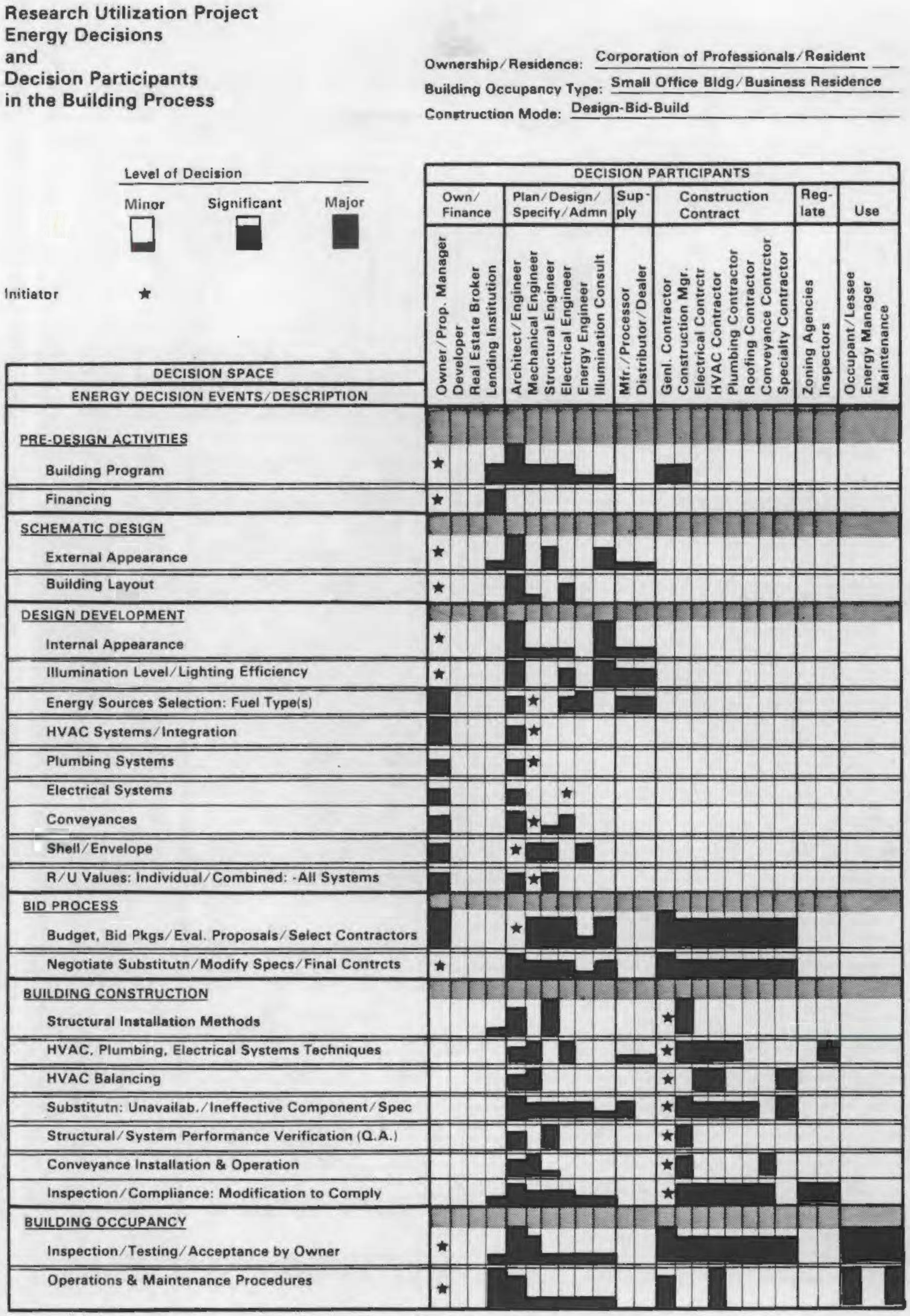

FIGURE 2.7. Decision Participants Identified As a Result of Industry Interviews

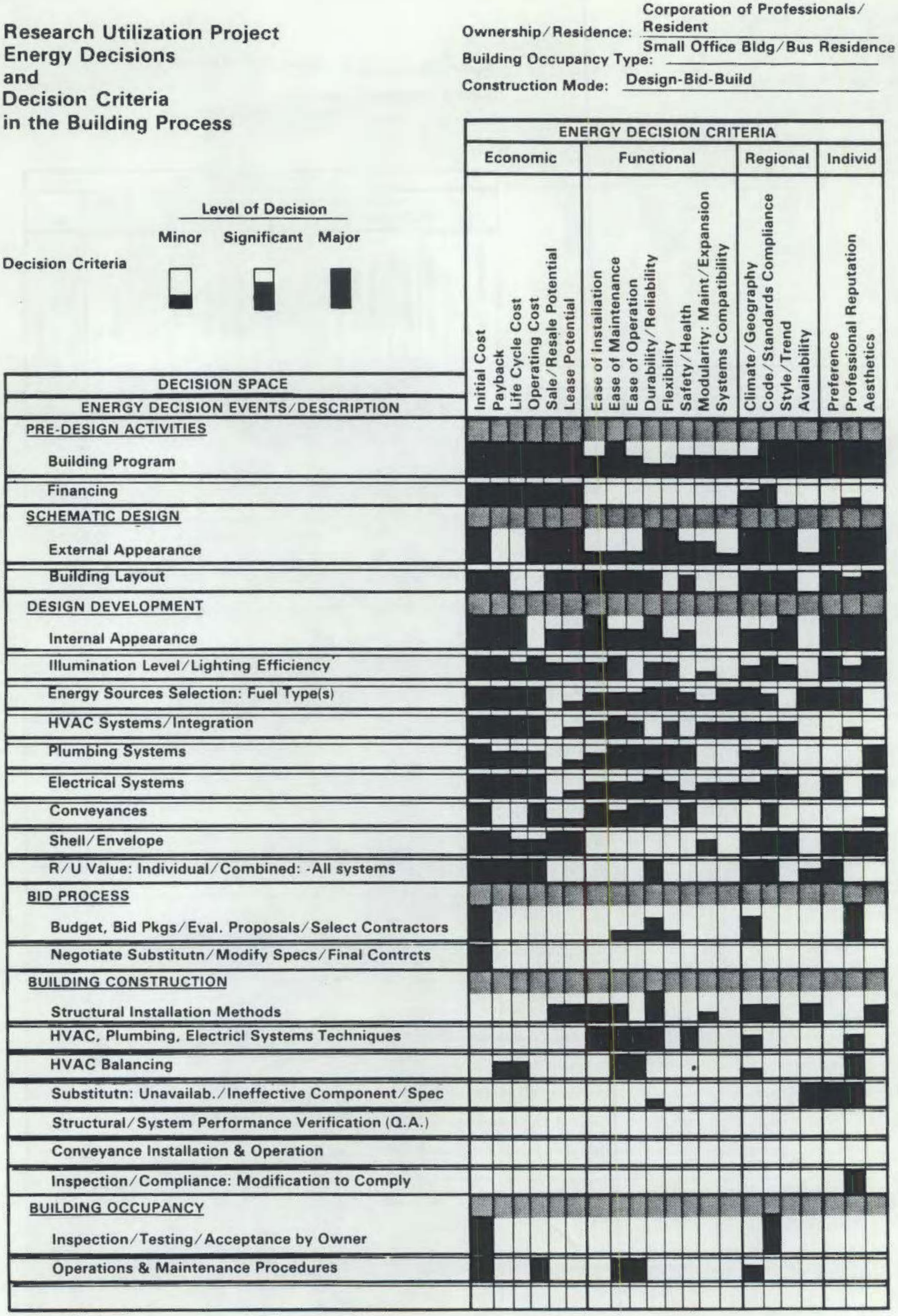

FIGURE 2.8. Decision Criteria Identified As a Result of Industry Interviews

A review of Figure 2.6 reveals the importance of the building owner as the initiator of energy saving techniques in the predesign and schematic design building phases. The owner usually selects the location and the orientation of the building, decides on the amenity level, and arranges for financing.

The role of the initiator shifts to the mechanical engineer during the design development phase. The mechanical engineer usually recommends the energy source, the plumbing system, the HVAC system, the conveyances, and the appropriate insulation values. The building owner usually decides the internal appearance and the illumination levels. Selection of the electrical system is usually left to the electrical engineer, and the building shell to the architect. The building owner continues to be influential during the design development phase by having approval or veto power over many decisions.

The bid phase brings the construction contractors into the decision process, and they continue to play an important role throughout the construction phase. The general contractor becomes the initiator during the building construction phase. Each contractor exerts some influence over the decision to use or to reject an energy-saving device or technique, but the ultimate authority lies with the general contractor. In the building occupancy stage, the owner becomes the initiator once again.

Figure 2.7 shows the criteria considered by these participants at each building phase. The emphasis during the predesign, schematic design and design development phases is on economic and functional criteria, since the building owner is the initiator or a major participant in these building phases, and since the owner will also be an occupant after the building is completed. In most cases only one or two of the economic criteria listed will be considered by a participant during a building phase.

Since the architect is a major participant in the first three building phases, individual criteria (principally professional reputation) become major considerations. Neither the architect nor the engineer wants to be associated with a building that is an "eyesore" or that does not operate properly, because of the immediate results and subsequent damage to their professional reputations.

Criteria importance shifts towards the functional as the building enters the construction phase. Ease of installation, maintenance, and operation are of primary concern to the general contractor and other major participants.

In the building occupancy phase, economic criteria are once again considered because the owner will eventually become an occupant of this building.

2.7. SUMMARY

The decision to use or reject an energy saving technology in the buildings industry is a very complex process. During any building phase, several participants may be involved using a number of decision criteria. In addition, the combination of participants and criteria can change with the decision process drivers.

A model was developed for describing the relationship between the four dimensions of the decision process, and a method for displaying this information was presented. Data were collected from industry representatives, and samples of these results were presented in the form of completed decision matrices.

One or more workshops should be conducted in which all participants have an opportunity to interact in a forum allowing for clarification of nomenclature and concepts. There is no standard nomenclature operating throughout the construction industry. Different nomenclatures are used by tradesmen, contractors and designers, and regional differences also are encountered. This workshop could help to solve some of the definitional problems encountered in work to date. The workshop participants would be carefully selected to represent the various participant groups and to ensure that a variety of process drivers were represented.

A key conclusion from this effort is that throughout the life of a building, several individuals simultaneously exert considerable influence in making specific decisions. Thus, they exert de facto veto power over the important energy decisions.

An example of how to use the type of information presented in Figures 2.7 and 2.8 follows.

Let us assume that it is desired to present information on a new concept for saving energy that affects the external appearance of a building that is owned by a corporation of professionals who will occupy part of the premises.

The information (see Figure 2.7) will need to go to, or be readily available to, the owners and the architect/engineer. Additional decision influences may include the lending institution, the mechanical structural electrical and energy engineers, the illumination consultant, and the general contractor/construction managers.

A number of concerns will need to be recognized and dealt with in the information that is supplied about the new concept. These concerns go far beyond that which can be dealt with using the usual technical information about the life of the surface, etc. The concerns that need to be dealt with can be identified by looking at the criteria by which concepts affecting the external appearance are accepted or rejected (see Figure 2.8).

The economic criteria that are most important are the initial cost, the operating cost, sale/resale potential and the lease potential. The most important functional considerations will be durability/reliability and flexibility to meet a variety of future renters' needs. The other functional criteria will also be important. All of the regional and individual criteria will also be important. <u>All of the listed criteria generate concerns that may need to be dealt with before the new concept is applied!</u>

There are a number of complex issues involved in selecting the proper transfer mechanisms for transferring the information to the decision makers shown above and in dealing with the concerns of these decision makers. These issues are discussed in Chapter 4.0.

An example of how to use this type of information [illegible] presented in Figures [illegible] and 3.2 follows.

[illegible] an architect [illegible] is interested in general information on a new concept for storing energy that affects the external appearance of a building so that it would need a consideration of [illegible] which will become part of the premises.

The information (see Figure 3.[illegible]) [illegible] used to [illegible], or the creation [illegible], the [illegible] the [illegible] among, additional considerations [illegible] as may include the [illegible], the [illegible] appropriate [illegible] and energy equipment, the construction consultant, [illegible] the construction engineers.

A number of concepts will [illegible] and [illegible] information that is [illegible] [illegible]. These concepts [illegible] more information can be [illegible] the usual technique [illegible] and the type of the product, etc. The [illegible] that need to be [illegible] can be [illegible] location of the [illegible] concepts [illegible] external concepts are accepted or rejected [illegible] Figure 3.[illegible].

The economic [illegible] are [illegible] important [illegible] the [illegible], the [illegible] and the local potential. [illegible] functional considerations [illegible] the [illegible] and the ability to design [illegible] future [illegible] needs. The [illegible] with [illegible] of the [illegible] and [illegible] will be important [illegible] of the [illegible] [illegible] that are [illegible] with [illegible] the [illegible] is [illegible].

There are a number of [illegible] involved in [illegible] the [illegible] [illegible] for transferring the information to the [illegible] and [illegible] that the concepts of these [illegible]. These issues are discussed in Chapter 4 [illegible].

3.0 A SEGMENTATION OF THE USERS OF BUILDING ENERGY CONSERVATION RESEARCH

The purpose of this chapter is to characterize the users of building energy conservation research as discrete market segments, or subsets of the building industry. This enables the targeting of formatted information to appropriate and well-defined audiences within the industry. A structure for the segmentation is developed, and data and information on each segment are presented. The relationship between the decision process model and the user segmentation is described in terms of how these tools can be synergistically employed to enhance technology transfer.

The building industry is partitioned into major divisions that correspond to the decision maker archetypes specified in the decision process model. This structure enhances the utility of the decision process model by associating decision makers with industry groups that influence energy conservation opportunities in the real world. Each division is then further divided into industry segments. Data to help focus the development and targeting of information to the appropriate audience are presented for each segment.

The data presented here represent a beginning rather than a conclusive characterization. The data sources in the open literature rarely present the opportunity to correlate information. Variations in definitions, coverage, scope and accuracy make it impossible to integrate statistics from disparate sources. The structure for disaggregating each industry segment has been motivated partly by the availability of data, and partly by considerations of what would be useful to research managers in planning effective technology transfer components to their programs.

Section 3.1 describes the user segmentation as a tool for use with the decision process model, and illustrates the advantages of using the segmentation to target information. Section 3.2 describes the structure and data sources used to develop the segmentation. Section 3.3 and Appendices A and B present data and information on each of the user segments.

3.1 LINKAGE WITH THE DECISION PROCESS MODEL

This section describes how to integrate the use of the decision process model and the user segmentation in planning technology transfer programs. It also describes how the data and information presented for industry segments can help narrow the focus of information transfer to the most appropriate audience.

The segmentation of building energy conservation research users is a tool to be used with the decision process model. The decision model maps the interactions of conservation opportunities and decision makers. The user segmentation details what firms and individuals in the industry comprise a category of decision makers. Knowing this is the first step in defining a specific audience that can affect the adoption of an energy conservation technology.

The greatest advantage of segmenting the industry is that it provides the means to focus the targeting of information beyond the first cut of identifying decision maker types with broad divisions of firms and groups of individuals in the industry. When fully developed, the user segmentation will provide the capability to target information to the most appropriate group of individuals for a given energy conservation opportunity. This group would be much smaller and more manageable in terms of communications than a broad category of decision makers specified in the decision process model.

For example, if the decision model identifies the architect as a key decision participant, the information in the industry segmentation can identify architects who are likely to have the most influence on the adoption of a technology. First, the segmentation identifies architectural firms that specialize in the building type in which the conservation opportunity exists. Second, it locates the area of greatest activity for that type of construction in the nation. From this information, tremendous amounts of resources can be saved that would otherwise be spent trying to reach all architects.

The connection between the decision process model and the user segmentation is that it identifies groups of firms and individual practitioners in the building industry that are portrayed in the model as decision makers. The advantage of segmenting the industry is that it provides the ability to target information to those subsets of firms and individuals that represent the greatest potential for adopting energy conservation technologies.

3.2 USER SEGMENTATION

The overall structure of the segmentation is presented in this section. Information on the geographic distribution of firms and construction activity and information on the distribution of construction activity by building type further defines the structure. This information applies across major divisions in the segmentation. Issues associated with the collection, analysis and presentation of data on industry segments are discussed.

The importance of segmenting the potential users of building research is that each segment performs a distinct functional role in the building process. Each segment has different decision criteria, information needs and sources, and customary formats. Segmenting the industry allows research managers to more sharply focus technology transfer programs.

3.2.1 Structure and Crosscutting Data

The major divisions corresponding to decision maker archetypes in the decision process model are as follows:

- Ownership/Development
- Finance
- Design and Development
  - Architecture
  - Engineering
- Materials and Components Manufacturing and Supply
- Construction Contracting
- Code Officials
- Building Operation
- Education.

A useful framework for disaggregating industry segments within these major divisions is by building use type. This allows for more focused targeting of information on technologies that typically apply to specific building types.

Detailed information on firms that specialize in certain building types is available for major portions of the Design and Development Division. Pro-File, the directory for the American Institute of Architects, provides approximate percentage distributions of business volume by building type for each member firm. The membership directory for the American Council of Consulting Engineers provides a similar, though less detailed, breakdown.

Figure 3.1 provides a means to gauge the relative activity of design professionals and construction contractors according to building use type. The average dollar volume of new building construction for the years 1981 through 1984 is given by building use type. This represents appproximately 70% of all new construction, the remainder being non-building construction (highways, telephone and telegraph, mining structures, sewers, etc.).

The relative levels of activity shown in Figure 3.1 give a rough breakdown of the percentage of activity in each segment. The limitations to using this gauge are that the non-building and industrial portions of construction activity are not included, and that the relative involvement of any given industry segment varies from building type to building type.

However, no other data sources were found, other than the membership directories mentioned above, that differentiate firms by the type of buildings they design or construct. These limitations can be addressed qualitatively by making some reasonable assumptions. It is reasonable, for example, to assume that engineering services for industrial and some non-building projects would be fairly intensive, and that architectural services for those categories would be less intensive. For the categories listed in Figure 3.1, both architectural and engineering services would be less intensive for single unit houses than for offices, or other commercial buildings. Non-residential farm buildings would be even less intensive.

These contraints limit the ability to quantitatively disaggregate industry segments by building type specialty. However, this does not preclude the qualitative application of segmentation by building type. This allows for further delimiting a target audience.

A second dimension for disaggregating industry segments is geography. This is particularly helpful for prioritizing support for broker organizations such as state energy offices, local chapters of national organizations, etc. Potentiating the technology transfer activities of local industry associations takes advantage of existing communications channels and trusted relationships that

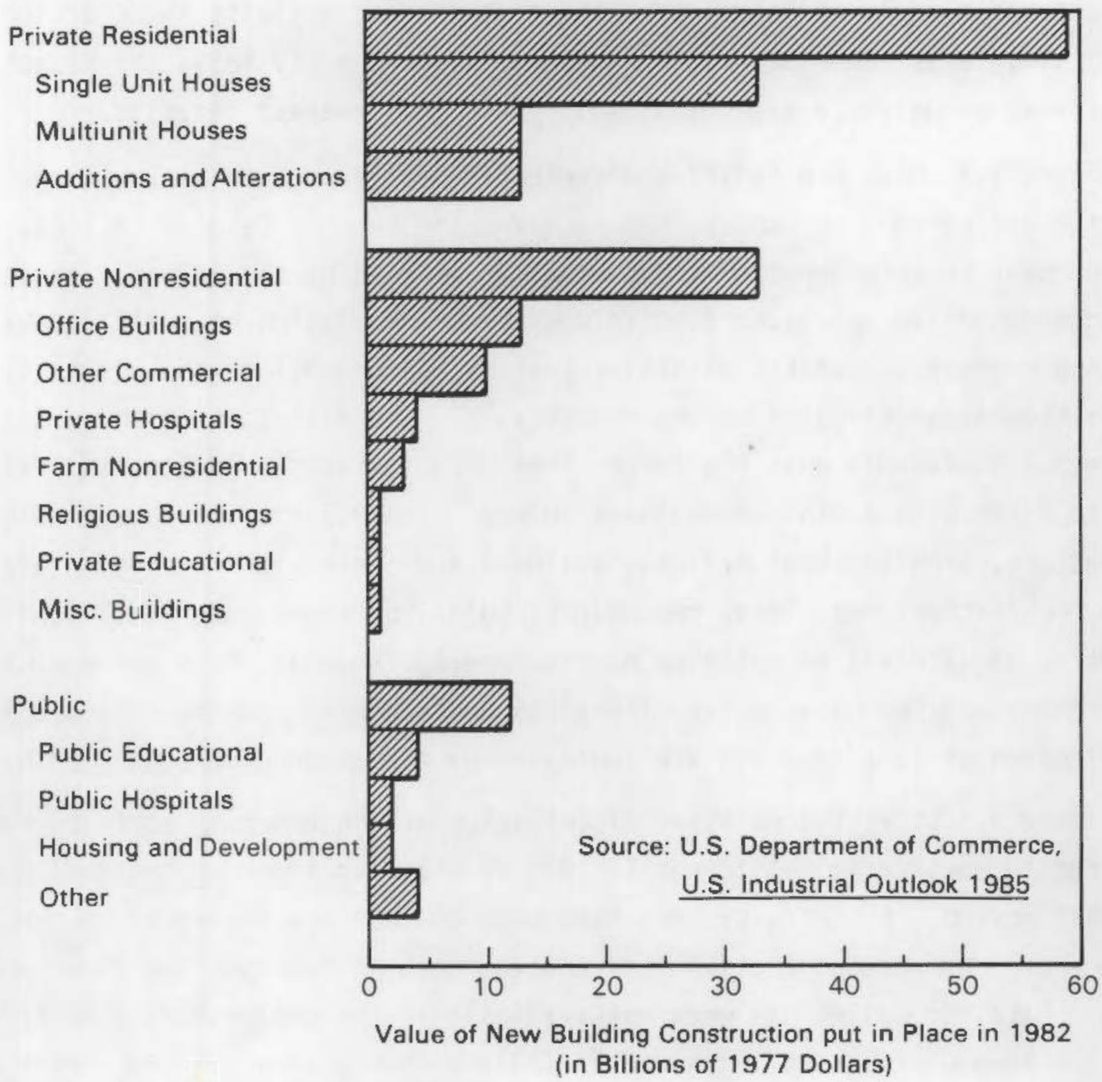

FIGURE 3.1. 1983 Dollar Value Distribution of Construction by Building Type

have been established over time. This leverages the impact of federal technology transfer resources. Figure 3.2 shows the relative distribution of single family dwelling construction activity for 1982 in terms of dollar value. States with less than $800,000,000 are indicated by the absence of a bar graph. This graphic clearly indicates that the most intense activity is occurring in California, Texas and Florida. This allows us to sharply focus the targeting of information on those areas that will yield the greatest benefits.

Figure 3.3 shows the relative distribution of firms serving the home-building and remodeling market that received the Sweet's Catalog in 1984. This is important because Sweet's is universally regarded by the industry as the most comprehensive and authoritative source of information on building materials and products. Sweet's maintains that it reaches 95% of the business volume in the design division of the industry.[a] The distribution shown in Figure 3.3 represents only the large firms because Sweet's limits its distribution to firms with a minimum business volume. These firms include builders and contractors, architectural offices, builders and contractors employing architects, contractor remodelers, remodelers, building material dealers, dealer-builders, industrialized building manufacturers, federal, state and municipal departments and buying agencies, libraries and schools. States with catalog distribution of less than 400 are indicated by the absence of a bar graph.

Figure 3.4 shows the relative distribution of construction activity for multifamily residential buildings in 1982 by state in terms of the dollar value of construction. States with less than $200,000,000 are indicated by the absence of a bar graph. Activity is concentrated in Florida, New York, and Texas. Data for California were not available in the preliminary statistics from the Bureau of Census, although it would probably be a primary target also.

Figure 3.5 shows the relative distribution of firms engaged in the general building and renovation market that received Sweet's Catalogue in 1984. Since the residential and industrial markets are listed separately for catalogue distribution, this is a good representation of large firms engaged primarily

(a) Personal communication with Miriam Eldar, Sweet's Division, McGraw-Hill Publishing Company, New York, New York.

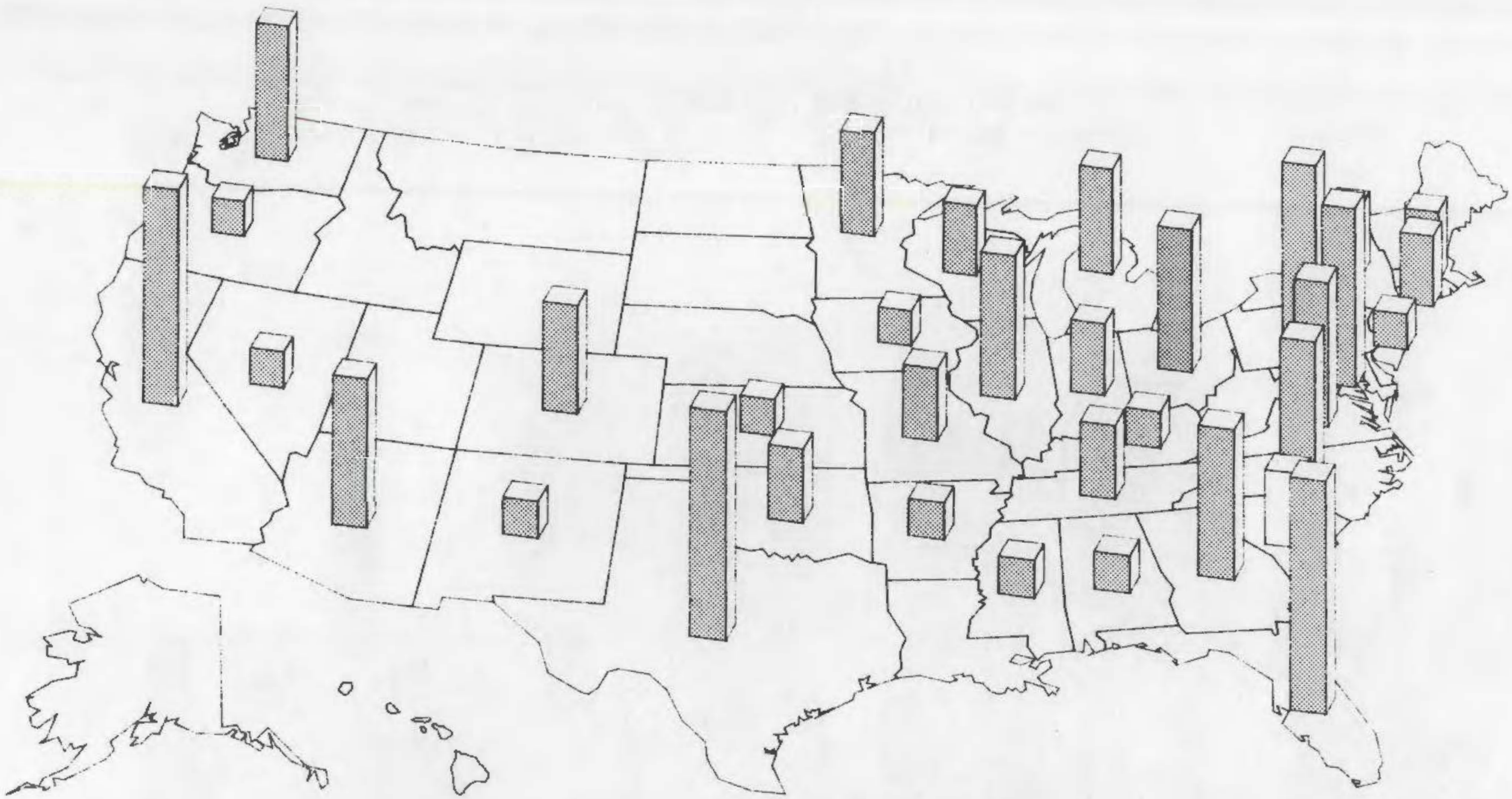

FIGURE 3.2. 1982 Relative Distribution of Single-Family Residential Construction Receipts (U.S. Department of Commerce, Bureau of Census, 1982 Census of Construction Industries - Preliminary)

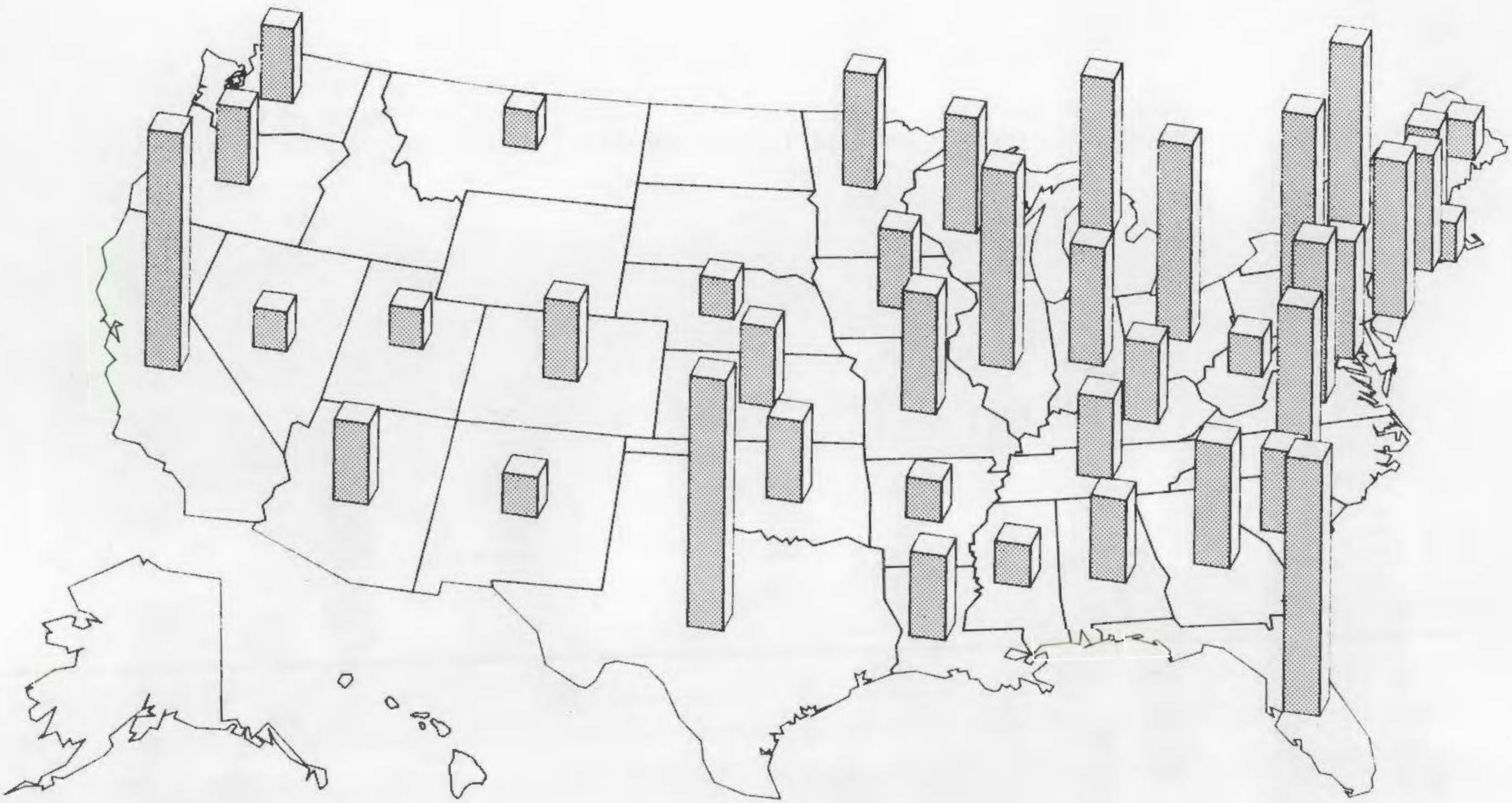

FIGURE 3.3. 1984 Relative Distribution of Sweet's Catalog to the Homebuilding and Remodeling Market (Sweet's Division, McGraw-Hill Publishing Company)

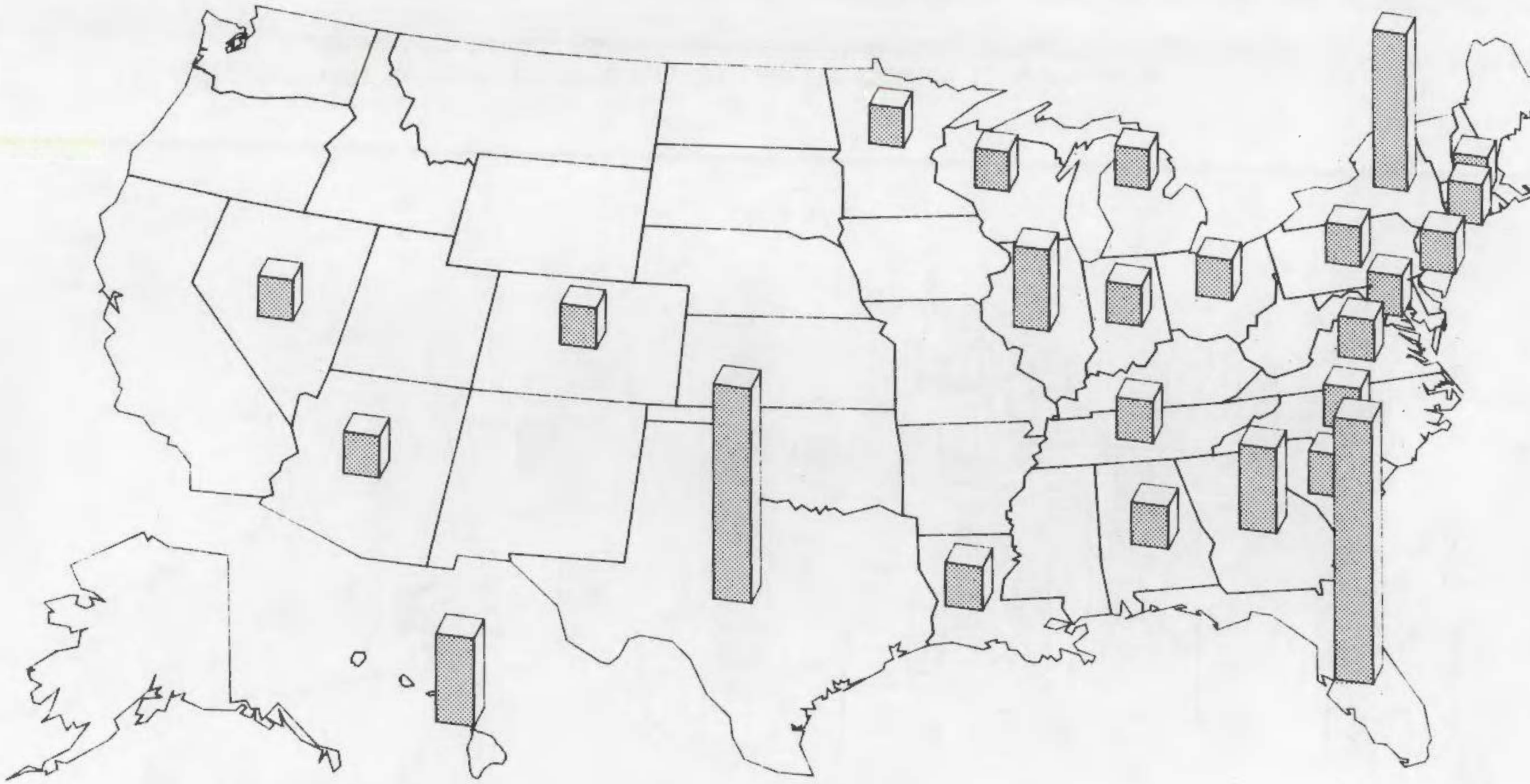

FIGURE 3.4. 1982 Relative Distribution of Dollar Volume in Multi-Family Housing (U.S. Department of Commerce, Bureau of Census, 1982 Census of Construction Industries - Preliminary)

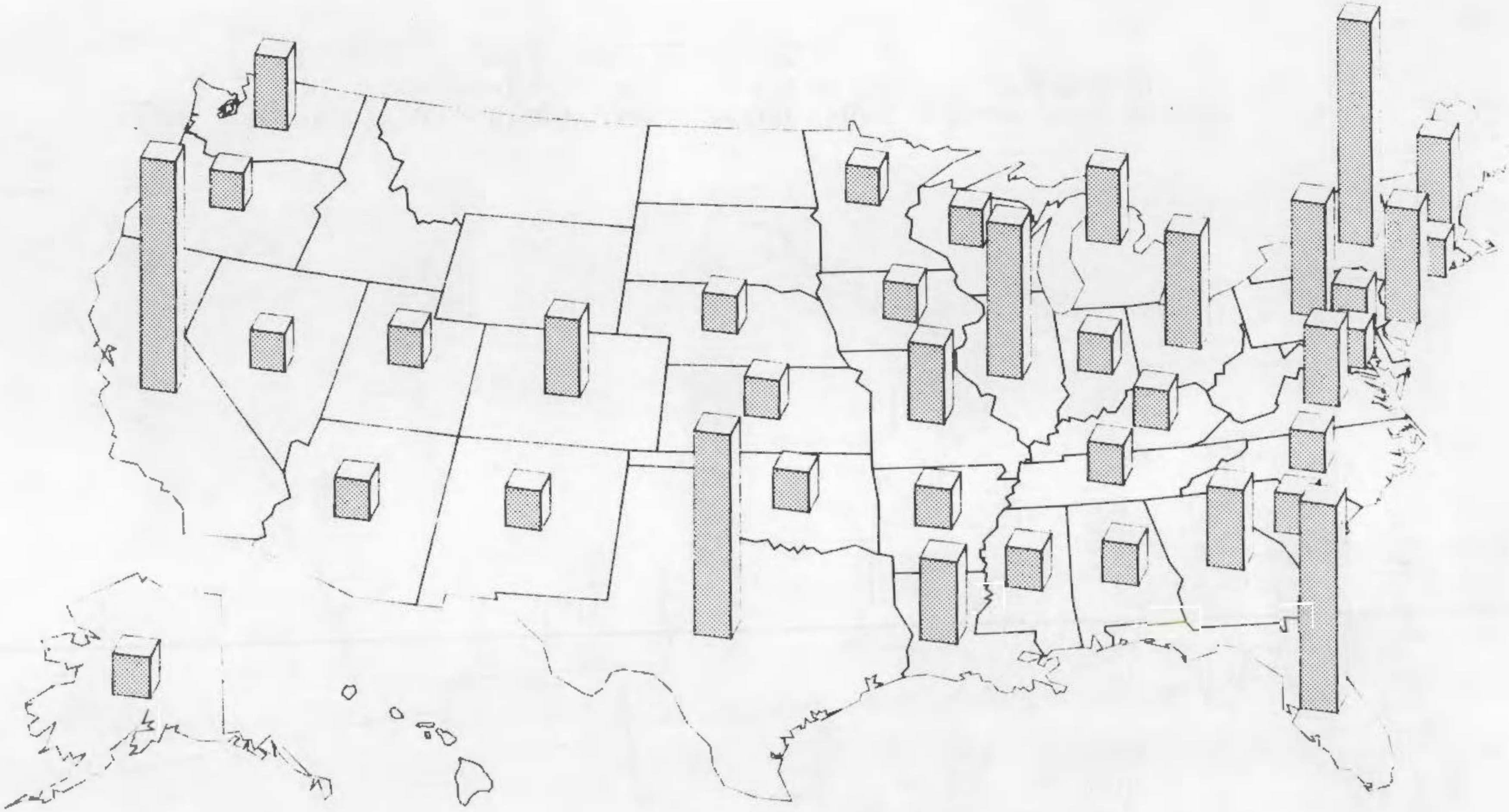

FIGURE 3.5. 1984 Relative Distribution of Sweet's Catalog to the General Building and *Renovation Market* (Sweet's Division, McGraw-Hill Publishing Company)

in the commercial market. States with catalog distribution of less than 400 are indicated by the absence of a bar graph. Included in this distribution are architectural offices, architectural and engineering offices, general contracting firms emoloying architects, contracting companies employing architects and engineers, specification consulting firms, building design engineers, consulting engineers, engineering and general contracting firms, general contracting firms, construction management firms, state and municioal departments and buying agencies, corporate building departments, schools, libraries and plan rooms.

Figure 3.6 shows the 1982 relative distribution by state of employees in firms engaged in providing architectural and engineering services. States with less than 12,000 employees are indicated by the absence of a bar graph. Some care should be exercised in interpreting this data for three reasons. First, many architects and some engineers are not accounted for because they are sole proprietorships. Second, these data do not distinguish among building types (industrial vs. non-industrial) or between building and non-building construction. Third, many of these employees are engaged in the design and management of foreign construction projects, which account for 15% of billings for the top 500 design firms (U.S. Department of Commerce 1985). Despite these limitations, this information is useful for indicating where the concentrations of design professionals work.

Figure 3.7 shows the relative growth in number of employees in firms engaged in providing architectural and engineering services between 1977 and 1982. Since this graphic is derived from the same data used in Figure 3.6, it has the same limitations. It is, however, useful for tracking growth in absolute terms.

3.2.2 Data and Information Sources

The open literature oresents a formidable challenge in gathering useful quantitative information at the industry segment level. Data are usually presented at a level either above or below that of the industry segment. Furthermore, industrial and non-building construction projects are often lumped in with commercial and residential building projects. And finally, the professional association memberships used include both building and non-building construction personnel.

FIGURE 3.6. 1982 Relative Distribution of Design Professionals (U.S. Department of Commerce, *Bureau of Census*, 1982 Census of Service Industries - Preliminary)

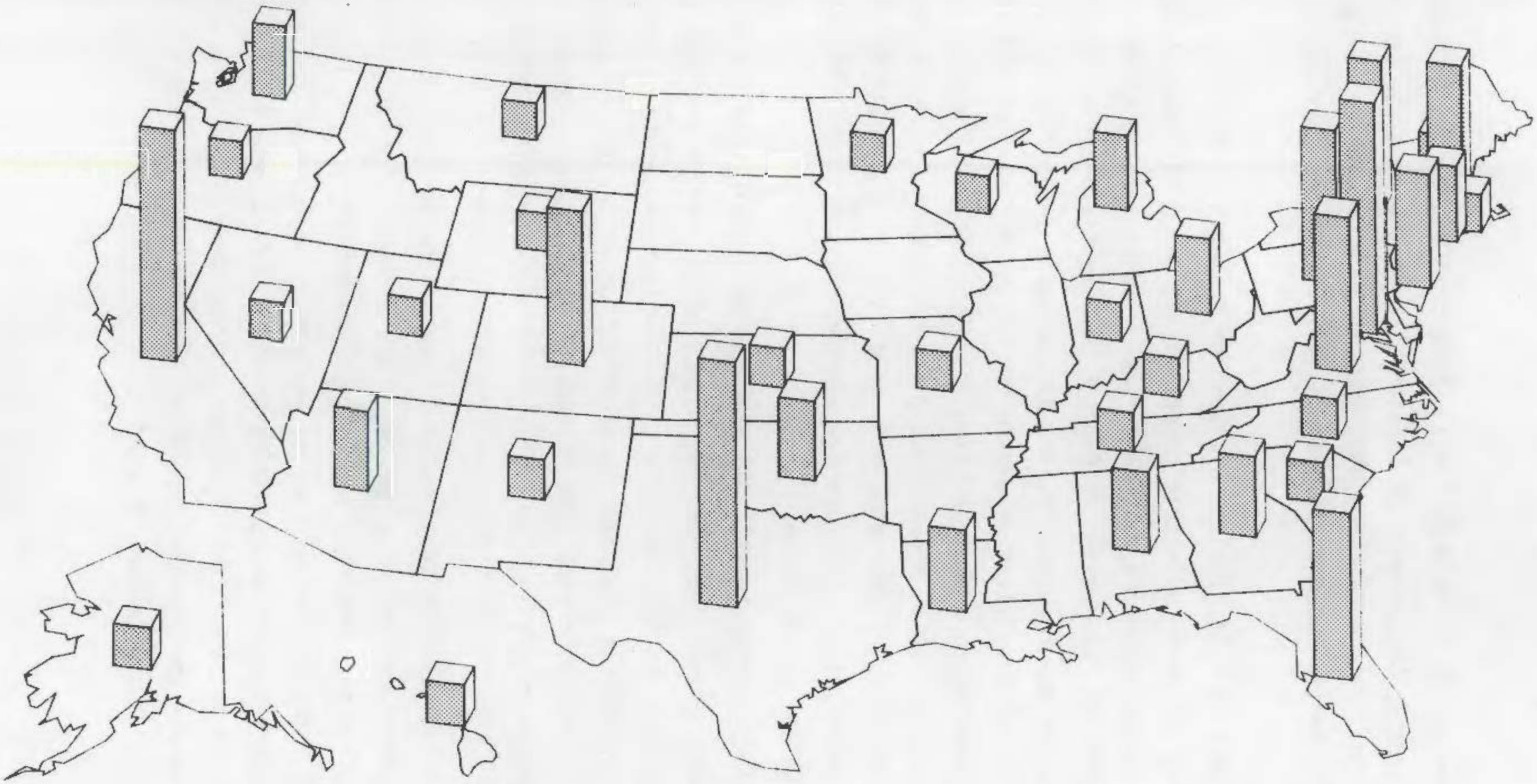

FIGURE 3.7. Relative Growth of Professionals Employed by Firms Engaged in Providing Architectural and Engineering Services, 1977 to 1982 (U.S. Department of Commerce, Bureau of Census, 1982 Census of Service Industries - Preliminary)

The data presented in Appendices A and B have been aggregated from the U.S. Department of Commerce, the Bureaus of Industrial Economics and the Census, and the open literature. Some data from these sources have been extrapolated and/ or interpolated to derive information that is useful in characterizing industry segments.

Through its catalog file, Sweet's Division of McGraw-Hill Publishing Company maintains a vital transfer mechanism by linking building products manufacturers with the design community that specifies building materials and products. Quantitative information on Sweet's Catalog distribution is presented in Appendix C for two reasons. First, as mentioned in Section 3.2.1, the catalog reaches 95% of the dollar volume in the design division of the industry. This comprehensive coverage qualifies its distribution as a good indicator of geographic distribution of business. Second, Sweet's segments the design community differently from both this study and the U.S. Department of Commerce. This segmentation structure can provide additional insight into information targeting in some cases.

The Uniform Construction Index (UCI) provides an organization for the materials and components of manufacturing and supply divisions but provides no data on the firms that comprise this division. The American Institute of Architect's (AIA's) Masterspec system and the organization of Sweet's catalog are variants of UCI. This index does show the extent to which each segment in the materials and components division could be further disaggregated, which might be helpful in targeting information on very specific research results.

A statistical data base on portions of the buildings industry is maintained by the U.S. Department of Commerce, Bureau of the Census. This data base is valuable for tracking the construction contracting segments of the industry. The materials and components manufacturing and supply segments of the industry in this data base are classified according to the Standard Industrial Classification (SIC). While this structure aggregates production of goods in ways that do not reflect the way the industry perceives market divisions, the quality and comprehensiveness of the data make it useful.

A final primary data source is the U.S. Department of Commerce, Bureau of Industrial Economics (BIE). Most of the information in Appendix A is derived from BIE's Industrial Outlook series and from the Bureau of Census' Census of Construction Industries (preliminary). These data are organized as follows:

- Number of establishments: Establishes a reference point for the extent of coverage necessary to achieve full market penetration for pertinent information.
- Number of establishments with 20 or fewer employees: Gives some indication of the size distribution of firms. If the typical firm in the industry segment is small, the targeting of information is simpler than if the typical firm is large and complex.
- Percent of industry shipments accounted for by 4 largest firms: Gives an indication of the concentration in an industry segment. If the level of concentration is high (as it is, for example, for the glass manufacturing industry segment), the most effective strategy is to target information directly to the largest firms. This allows for an economy of federal resources for technology transfer.
- Total employment: Provides a bench mark for the number of individuals who must receive and understand information on research results to achieve full coverage. This statistic must be tempered by the fact that not all employees in a given industry segment have the authority to exercise influence over energy conservation decisions.
- Value of industry shipments: Especially vis-a-vis other industry segments, these data provide a reference for the relative business influence over the decision making process exerted by the industry segment.
- Value added: Provides a reference for wages and salaries paid in an industry segment.
- Major producing states: Provides an idea of geographic concentration of an industry segment, allowing for better targeting of information, particularly if state and local broker organizations can be employed to leverage federal resources.

3.3 USER SEGMENTS: DATA AND INFORMATION

This section provides statistical data and information on trends and market factors that impinge on ways to effectively transfer information to specific segments of the buildings industry. Each subsection may be regarded as an introduction to the segmentation within a major industry division. The previous discussions on the distribution of firms according to building use type and according to geography generally apply to each segment described below.

3.3.1 Ownership/Development

Owners are nearly always the strongest potential influence over decisions that affect energy conservation opportunities. Their actual influence varies not only with the factors specified in Figure 2.5, but also with the number of principals that compose the ownership function, and with their personal degree of involvement in the building process.

Building owners are the most diverse group in the industry, ranging from corporate entities to professionals to investors. This diversity is illustrated by the following summary prepared for the Federal Energy Administration (Booz, Allen and Hamilton 1985).

Education

- Highly diverse: 6th grade to PhD, technical and non-technical
- Masters degrees in business and finance most common
- Generally the larger the ownership, the greater the education.

Experience

- Highly diverse
- Varies with size of ownership
- On the average, related experience tends to increase with company size.

Operational Methods

- Varies with size of ownership, building type, size and use, and number of tenants
- On the average, division of labor increases with company size

- Operational functions include:
  - general management
  - administrative and legal
  - finance
  - marketing
  - production.

Professional Methods

- Relate to operational functions and include:
  - technical guidance
  - technical expertise
  - earnings/income
  - new business opportunities
- Degree to which he or she relies on outside expertise (either within his or her own firm or by contractors) varies with company size and magnitude of holdings.

Developers' potential influence varies by the degree to which they have invested in the project. Developers are an independent group whose overriding purpose is to broker the elements necessary to create a building in response to a perceived need. Their independence is evidenced by the nature of their service, and by the fact that, despite their inclusion as a reporting category, limited data are available from the Census of Construction Industries.

The following industry segments are included in the ownership/development division:

- corporate owners
- owners with commercial franchises
- operative builders
- other owners
- commercial developers
- real estate brokers

This taxonomy is not fully developed due to a lack of data on the various owner types. Real estate brokers are included here because they directly represent building owners, and because they can influence energy decisions by assessing the salability of a building.

Corporate Owners

This segment refers to corporations, stereotypically large corporations, that own and operate significant real estate holdings. These are distinguished from other segments because they usually employ in-house staff to plan, design and develop their buildings. Corporate decision making is more formal and complex than other situations. Several levels of management might be involved. Large corporations typically have energy managers that oversee (usually with no line authority) all building operations. No statistics are available for this segment.

Owners with a Commercial Franchise

This type of owner is segregated from others because of the significant growth in franchise operations, and because the franchising organization may play a major role in decisions that affect energy conservation opportunities. In 1985, 481,000 franchise establishments will account for sales of $459 billion (U.S. Deoartment of Commerce 1985; Hotel and Motel Management 1984). Sophisticated franchising firms like McDonald's Restaurants not only have considerable influence over the design of buildings, but also conduct their own energy research and offer professional design services. Franchising firms using commercial buildings for operations offer a unique opportunity to reach many building owners through an existing infrastructure.

Operative Builders

Establishments in this industry segment are engaged in the construction of single family houses and other buildings for sale on their own behalf rather than as contractors. This includes speculative builders and condominium developers.

	1982
Total Number of Establishments	14,045
Total Number of Establishments with 20 or Less Employees	N/A

Percentage of Industry Receipts Accounted for by 4 Largest Firms	N/A
Total Employment	108,253
Value of Industry Receipts	$15.8MM**
Value Added	$5.7MM

** $6.7MM of this was subcontracted out.

Major Producing States: TX, CA, FL

Source: 1982 Census of Construction Industries (prelim.)

Other Owners

This segment represents the vast majority of building owners. It is defined simply to include the diversity of ownership described at the outset of this section. No further statistical analyses were found to characterize this segment.

Commercial Developers

Establishments in this industry segment are engaged in subdividing real property into lots, except cemetery lots, and in developing it for resale on their own behalf.

	1982
Total Number of Establishments	6,036
Total Number of Establishments with 20 or Less Employees	N/A
Percentage of Industry Receipts Accounted for by 4 Largest Firms	N/A
Total Employment	41,577
Value of Receipts	$2.2MM

Value Added	$1.2MM

Major Producing States: TX, FL

Source: 1982 Census of Construction Industries (prelim.)

3.3.2 Finance

Major segments of the real estate finance industry are as follows:

- savings and loan associations
- mutual savings banks
- real estate investment trusts
- mortgage companies
- commercial banks
- life insurance companies
- pension funds
- government programs
- unconventional sources.

Although the influence of financiers on conservation decisions can be significant, detailed information on every segment of the finance industry is beyond the scope of this report. The following summary is provided.

Savings and Loan Associations

SIC 612

Number of Associations *	3,391
Number of Branches *	18,060
Number of Offices *	21,451
Employment (000)	295
Assets ($ billions)	830
Mortgages ($ billions)	590
Total Savings ($ billions)	640

Passbook Savings ($ billions)	71

* As of September 30, 1982

Source: Federal Home Loan Bank Board and Bureau of Labor Statistics, as reported in 1984 U.S. Industrial Outlook, U.S. Department of Commerce 1984.

Life Insurance Companies

SIC 6311

Premium receipts (billion $)	118
Employment (000) *	539
Number of Companies	2,048

* Home office only.

Source: American Council of Life Insurance and Bureau of Labor Statistics, as reported in 1984 U.S. Industrial Outlook, U.S. Department of Commerce 1984.

Distribution of Life Insurance Company Assets, by Type, 1983

Assets	Value (billion $)	Percent of total
Corporate securities	280	42.3
Bonds	212	32.0
Stocks	68	10.3
Mortgages	149	22.4
Policy loans	55	8.3
Government securities	68	10.3
Real estate	22	3.3
Miscellaneous	89	13.3
Total	663	100.0

Commercial Banks
SIC 602

Number of banks *	15,031
Number of Branches *	39,775
Number of Offices *	54,806
Employment (000)	1,530
Assets ($ billions)	1,966
Loans ($ billions)	1,061
Investments ($ billions)	414
Deposits ($ billions)	1,498

* 1982 year-end data.

3.3.3 Design and Development

The design and development community is comprised principally of architects and engineers, although general and specialty contractors become involved in the design process from time to time. These professions specify what equipment and materials will be used in a building, their sizes and capacities and how they will be used in terms of building geometry and configuration.

A major source of potential confusion in the professional design division is the lack of one-to-one correspondence between professional functions and firm types. Any or all of the firm types listed below may employ any or all of the professionals listed. While it is the people who make the decisions regarding energy conservation opportunities, often the only identifiable way to reach them is through the firm.

Firm Type	Professional Title/Function
Architectural	Architects
Landscape-architectural	Landscape architects
Architectural engineering	Civil engineers
Engineering-architectural	Structural engineers
Interior design	Mechanical engineers
Corporate design and development	Electrical engineers
General contracting	Design technicians
	Interior design consultants

The following is a statistical summary of the portion of the design community conducted by the Bureau of the Census in SIC 891, engineering, architectural and surveying services. As discussed previously, sole proprietorships, a significant portion of this industry division, are not counted in these statistics. Establishments in this industry segment primarily perform services of a professional nature in the fields of engineering and architecture. Engineering services relate to both construction and non-construction services.

	1982
Total Number of Establishments	75,583**
Total Number of Establishments with 20 or Less Employees	N/A
Percentage of Industry Receipts Accounted for by 4 Largest Firms	N/A
Total Employment	566,517
Value of Industry Receipts	$33,532MM

Value Added

* For disaggregation and some detail, see writeup in text

** 1977 data

Source: 1984 U.S. Industrial Outlook, U.S. Department of Commerce.

Architect/Engineering Firms

Authoritative, complete and current data on the number, size, geographic distribution, and economic influence of architectural and engineering firms are not easily obtained, for a variety of reasons. While the Bureau of the Census, Bureau of Industrial Economics (BIE) does gather such information on a 5-year cycle in its Census of Service Industries (the latest was in 1982), there are several major difficulties with the Census' figures:

- There is a significant time lag between the gathering and the issuing of the data. The 1982 Census results, for example, are now available only in partial form. Complete reports will not be available until late 1985 or early 1986. In an industry deeply affected by market fluctuations, substantial changes can occur quickly and are not represented. Also, the building industry was severely depressed in 1982, so quantitative economic and market data cannot be considered typical.
- The census aggregates data on the basis of SIC 801, which includes architectural, engineering and surveying service firms. These types of firms are often very different in terms of their roles and influences in the building process. Some are not involved in buildings-related activity (and instead derive income from civil and other engineering and surveying work). No such distinctions are made in the BIE data.

In 1978 the BIE divided employment on a percentage basis within the payroll portion of this sector as follows:

Architects	11 percent
Engineers	23 percent
Engineering technicians	24 percent
Administrative and other	42 percent

- Only results from firms with payrolls are reported. Sole proprietorships and many forms of partnerships (both very common in architect/engineering firms) are not included, although the BIE does occasionally prepare estimates.

The result is generally that the Census figures are low in all categories and thus may not prove to be accurate when issued. The BIE has issued preliminary 1983 estimates covering this sector that are more or less within the ranges of estimates prepared by private sources (e.g., the BIE suggests that there are approximately 63,200 individuals employed as architects; in 1982 the American Institute of Architects (AIA) received data from state architectural registration boards suggesting that there were then approximately 62,000 persons with current architects' licenses).

Various professional associations and publishing organizations undertake similar estimates. A professional association may wish to know how many of all possible members the association may actually represent. The drawback of these estimates is that they may not count firms that are active and influential in the building industry but that are ineligible for association membership.

Architects and Architectural Firms

The AIA has two ongoing activities aimed at better understanding the dimensions of the architectural profession. Its membership is approximately 37,000 corporations.

- Individual architects. In 1982 the AIA gathered registration rosters from every state, arriving at a national total of just over 62,000. The AIA reports significant shortcomings with this approach, not the least of which stems from the fact that several states do not keep current or complete records. Nonetheless, the AIA will gather data from these rosters annually (no other organization at present does this) beginning this year. The AIA regards an estimate of 65,000 registered architects as conservative.

- Architectural Firms. Pro-File is a proprietary directory recently acquired by the AIA that contains information on architectural firms. It is generally recognized as a reasonably authoritative source. The edition currently in progress will list approximately 10,500 firms, down from the 14,860 listed in its predecessor. The decline reflects editing out of duplications and other faulty entries, as well as some business consolidation and attrition. Three factors that may be contributing to a trend of reducing or consolidating the architectural service sector are:

- the use of predesigned and pre-engineered modular housing
- the use of predesigned and pre-engineered metal commercial buildings
- the use of computer aided design.

The AIA also includes in its count of its membership those who pay supplemental dues, an indication of the number of persons with a proprietary interest in firms. In 1984 this number was 12,800. These figures are similar to estimates from BIE data which suggest that in 1982 there were 10,900 architectural firms. Knowledgeable AIA staff members generally agree that the ratio of individual AIA members to registered architects (that is, 37,000 to 65,000, or about 57%) would also apply to the number of AIA member firms compared with all architectural firms. This indicates a greater number of firms than suggested in BIE estimates. The AIA also confirms that by far the largest proportion of architectural firms (as much as 80 percent of the total) are firms with 10 or fewer employees. Further, it is reasonable to assume that the national distribution of architects follows the AIA's regional membership patterns shown in Table 3.1. As one final statistic, the AIA has a mailing list, no longer in regular use, of 13,487 firms.

The National Council of Architectural Registration Boards (NCARB), which is the association of state professional licensing agencies, reports that in mid-August 1984, there were 22,518 registered architects certified under NCARB procedures. This is to some degree a measure of the number of licensed professionals whose practices extend beyond the borders of a single state. (NCARB certification greatly simplifies the process of reciprocal licensing; a

TABLE 3.1. AIA Membership Count as of August 15, 1984

Geographic Regions	Associate Members[(a)]	Corporate Members[(b)]	Total Members
California	1171	5526	6697
Central States	539	2224	2763
East Central	106	681	787
Florida/Carribean	296	1790	2086
Gulf States	501	2010	2511
Illinois	179	1545	1724
Michigan	137	1078	1215
Middle Atlantic	516	2375	2891
New England	205	1948	2153
New York	350	2455	2805
North Central	244	1348	1592
North West	365	2549	2914
Ohio	130	1258	1388
Pennsylvania	126	1059	1185
South Atlantic	369	2055	2424
Texas	804	3579	4383
Western Mountain	398	2150	2548
New Jersey	129	942	1071
TOTAL	6565	36572	43137

(a) Associate members are individuals not yet licensed to practice architecture, but who are working in some capacity that will lead to eligibility to sit for the licensing examination.

(b) Corporate members are individuals who are licensed to practice architecture.

SOURCE: Data obtained by Thomas Vonier Associates, Inc. from records at AIA headquarters.

candidate normally is required to sit for only one professional licensing examination, the successful completion of which becomes the basis for licensing in a number of states.) NCARB certification is the closest thing in the profession to a "national" license. There are, however, many architects who no longer are active in the profession but maintain, for one reason or another, NCARB certification. Although NCARB gathers no information that would support the figure, NCARB generally subscribes to the estimate that there are presently approximately 65,000 registered architects in the U.S.

Engineers and Engineering Firms

There is some assurance that regardless of the method used to count architects, most of those included are professionals whose primary activity is in some way related to the design and management of buildings. This is not necessarily the case in the engineering disciplines, in which a single firm may employ a variety of professionals and undertake a wide range of projects, few or none of which are related to buildings. Additional data consulted for engineering firms were provided by the Census of Service Industries, and by some private sources.

Consulting Engineering magazine estimates a total of 16,786 engineering firms in the U.S. The American Consulting Engineers Council (ACEC) generally agrees with this estimate, although the council feels it is probably low. ACEC counted 4625 firm members in mid-1984 (ACEC has no individual members). The closest breakdown of these firms is a survey of member firms by ACEC that indicates, by percentage of the total membership, capabilities in the following areas potentially related to buildings:

Mechanical engineering	35 percent
Electrical engineering	32 percent
Structural engineering	46 percent.

ACEC estimates that its member firms employ about 199,000 individuals, many of whom are administrative and clerical employees. The American Society of Mechanical Engineers counted 88,710 members in mid-1984, but could offer no estimate of those active in buildings-related work.

Landscape Architecture and Design

The American Society of Landscape Architects (ASLA) estimates that there are approximately 25,000 persons in the U.S. practicing as landscape architects, approximately 7,000 of whom were members of ASLA in 1984. They also estimate that, in addition to many small sole proprietorships, there are approximately 2,000 firms (some of which are also architectural firms) employing landscape architects.

Other Groups

Additional study should be made of several groups of professionals whose influence in the building design process is substantial and increasing. These groups include, at minimum, lighting designers and interior designers. Since these groups are not counted as distinct occupations in Census surveys, the principal sources of information would necessarily be private associations such as the International Association of Lighting Designers (IALD), the Illuminating Engineering Society (IES), and the American Society of Interior Designers (ASID).

There is also a growing number of "design/build" firms, which, like the metal building industry, provide both design and construction contracting services.

Corporate Design and Development

Corporate design and development is considered a distinct segment of the design division because the concerns of these professionals differ from those professionals operating on a proprietary basis. Data on this segment are sparse, but it can be assumed that much of the "in-house" design capability is for industrial firms whose building needs are dictated by a manufacturing process. Commercial activity is presumed to be concentrated in the retail, restaurant, and hotel categories in firms that operate chains or franchises. Design services for corporations engaged in residential housing, manufactured housing, and manufactured metal buildings may also be included in this segment.

3.3.4 Construction Contracting

The construction contracting division is segmented along the following functional areas:

General contractors	Carpentering
Excavation and foundation	Glass and glazing
Structural steel	Building equipment
Concrete work	Printing, paper hanging and decorating
Electrical	Roofing and sheet metal

Plumbing, heating and air conditioning

Plastering, drywall, accoustical and insulation

Floor laying

Terazzo, tile, marble and mosaic

Data from the U.S. Department of Commerce are the most detailed for each of these segments, including primary data on activity by building type. These data are presented in Appendix A for each segment listed above.

Figure 3.8 shows the number of firms in each industry segment, as well as the total value of industry receipts in 1983 and value added. The value added portion of the bar chart basically represents wages and earnings for that segment. This provides a better indicator of the value of labor, while total receipts provide an indication of the relative budget responsibility for each of the contractor types. Representation of the number of firms in each category provides an indication of how widely dispersed firms are, and allows the reader to interpret the relative size of firms using the cost data.

3.3.5 Materials and Components Manufacturing and Supply

The manufacturing division is a primary technology transfer agent for the building industry as well as a primary source of innovation. It is also one of the most difficult segments to characterize, especially in quantitative terms, because of its large size and diversity. Detailed information on the following segments according to SIC code, is presented in Appendix B:

Fabricated structural metal
Prefabricated metal buildings
Steel metal work
Flat glass
Hydraulic cement
Concrete block and brick
Current carrying wiring divices
Non-current carrying divices
Lighting fixtures
Structural wood
Particle board

Ready mixed concrete
Concrete products
Brick and structural clay tile
Vitreous plumbing fixtures
Metal plumbing fixtures
Plumbing fixtures and brass goods
Sawmills and planing mills
Hardwood dimension and flowing
Softwood veneer and plywood
Millwork

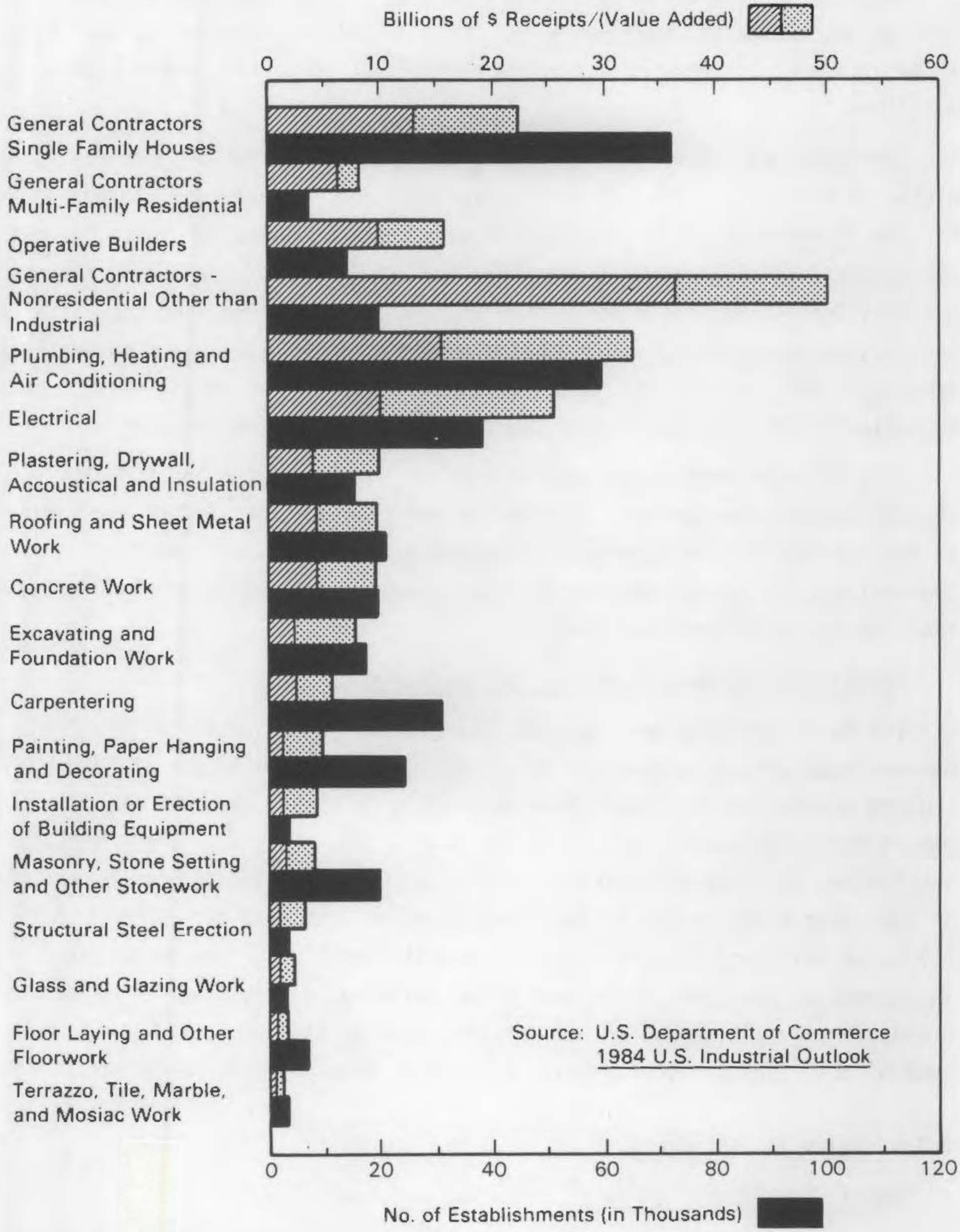

FIGURE 3.8. Summary of 1983 Construction Contracting Division by Industry Segment

Figure 3.9 shows the relative size of each industry segment in terms of 1982 dollar volume (in 1977 dollars). This describes the relative importance of each segment in terms of its product contribution to the composition of buildings.

Manufacturing and supply activities are primary sources of technical information on buildings. Product literature describes not only what is available for use in constructing buildings, but also the techniques for installation, the specifications, and the limitations for application. The supply function not only facilitates the distribution of product literature, but also provides the technical support for product use through knowledgeable distributors, sales personnel, and regional and local representatives. These people consult and communicate with both the specifying community and the construction sectors.

This division provides a major source of innovation for the industry through product development. The design and construction sectors are limited by the availability of materials and components. In a sense, design professionals simply select products and components for a given building, and then specify their configuration.

Metal Building Manufacturers, Designers and Builders

The Metal Building Manufacturers Association (MBMA) estimates that its members manufactured 51 percent of all nonresidential buildings of less than 150,000 square feet in floor area constructed in 1983. The MBMA has 34 manufacturing members, who account for most of the activity in this sector. The Systems Builders Association (SBA) is another organization which consists of just over 8,000 contractor/builders, many of whom also offer design services for metal buildings. These figures generally agree with figures obtained from the Bureau of the Census. Because these buildings rarely involve design professionals, but represent a substantial market and are actually designed, some of this industry's activities could also be classified as design services.

3.3.6 Codes and Standards

Model Code Organizations

Three national organizations maintain model building codes for states and municipalities to adopt as legal guidelines for construction. Each

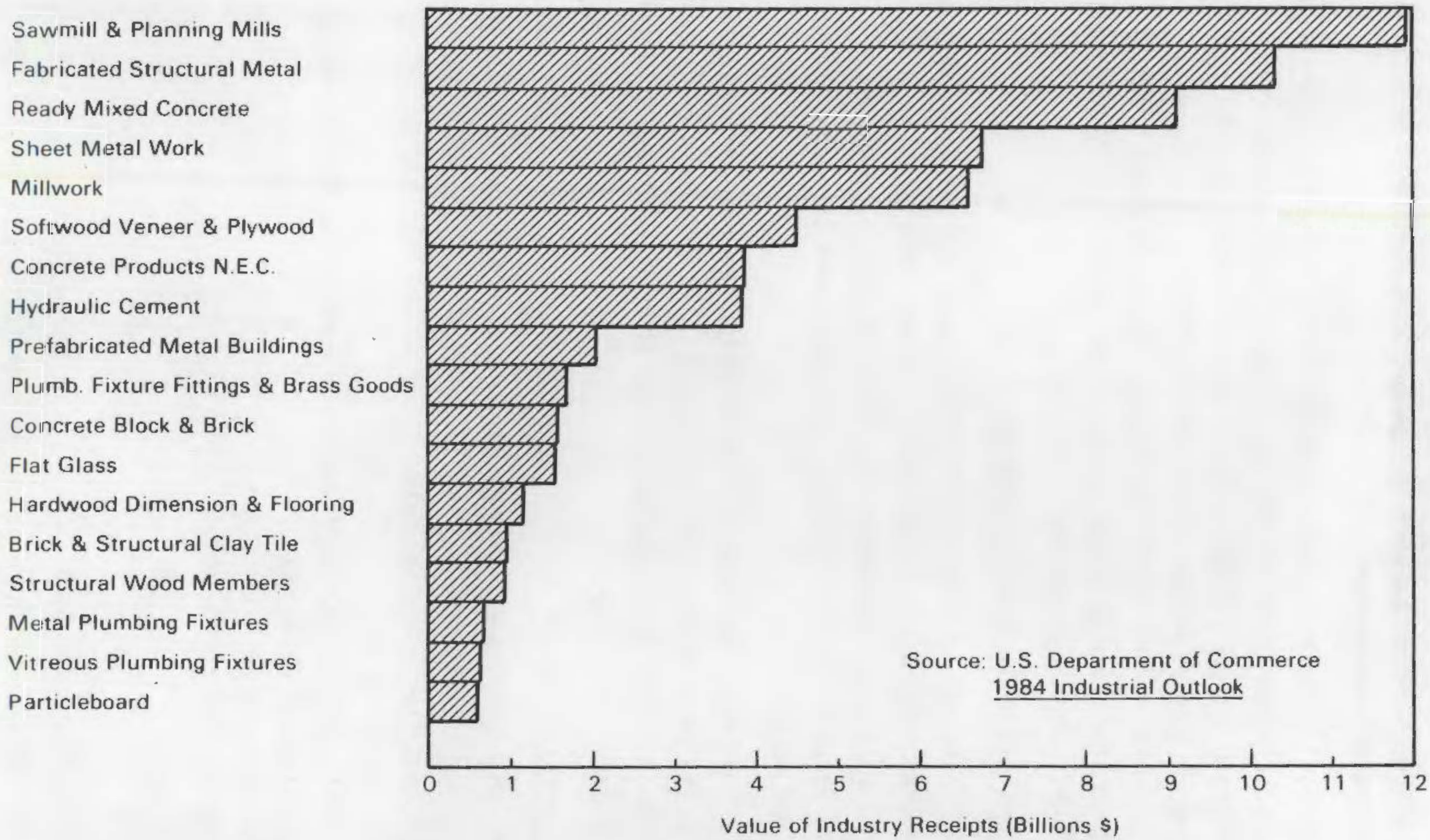

FIGURE 3.9. Materials and Components Manufacturing, Distribution of 1984 Receipts by Industry Segment

organization provides minimum standards on design, construction, and materials to insure public safety and welfare.

The International Conference of Building Officials maintains the Uniform Building Code, which predominates in the Western U.S. Building Officials and Code Administrators (BOCA) International, Inc. maintains The BOCA Basic Building Code, which is used primarily in the Eastern U.S. The Southern Building Code International maintains the Standard Building Code, which is prevalent in the south. Each of these organizations has its own procedures for modifying the model codes it maintains.

Building Codes Coordinating Organizations

The National Conference of States on Building Codes and Standards is the premier organization promoting building code uniformity coordination among states and municipalities. Its members are state and local government representatives, local building officials, architects, engineers, contractors, manufacturers, and others.

The Council of American Building Officials (CABO) serves as an umbrella organization for the three model code organizations. It acts as a clearinghouse for code changes, and it represents a membership of about 8,000 cities, counties, and states.

Standards Organizations

A number of organizations maintain standards that affect the buildings industry.

American National Standards Institute
Underwriters' Laboratories
American Society of Heating, Refrigeration and Air Conditioning Engineers
American Institute of Architects
National Fire Protection Association
Illumination Engineering Society.

3.3.7 Education

Architectural Schools and Educators

There are 102 degree-granting programs in architecture in the U.S. and Canada, employing approximately 2,400 full time faculty members and another

1,000 part time or adjunct faculty. The Association of Collegiate Schools of Architecture (ACSA) estimates that approximately 33,000 students are in architectural schools in a given year. Approximately 11,000 persons took the NCARB professional licensing examination in 1984 (about 40 percent of whom are expected to have passed). Although these individuals are generally not directly out of school (because they must serve an internship prior to qualifying for the examination), this number is useful as a general indicator of the numbers entering the professional ranks annually.

Other Education

Engineering degrees are offered at schools throughout the U.S. The curricula offered are fairly standard and usually contain considerable emphasis on energy. However, there are other educational opportunities. Some trade unions, notably the electrical works and plumbers' unions, require not only an apprenticeship, but also the successful completion of a multi-year night school curriculum.

[illegible] of Lutheran [illegible] approximately 11,000 students [illegible] approximately 11,000 [illegible] and about 40 percent [illegible] annually [illegible]

Other Education

[illegible] successful completion [illegible] school [illegible]

4.0 TECHNOLOGY TRANSFER MECHANISMS AND THEIR ENVIRONMENT

4.1. INTRODUCTION

The previous chapters established a framework for understanding the complex decision processes of the buildings industry and an overview of the texture of the industry. With the aid of this model, information on energy conservation can be presented to the appropriate decision makers. However, vehicles or transfer mechanisms are needed for presenting this information. Examples of these mechanisms are reports, brochures, trade publications, and manufacturer representatives. Selection of the most effective and efficient transfer mechanisms requires an understanding of the pathways by which information can reach the buildings industry and an understanding of the environment in which the transfer of information occurs.

Successful transfer of R&D information from laboratories to industry decision makers involves the activities of many broker organizations as well as interactions among building industry decision participants (see Figure 4.1).

Transfer mechanisms must be focused on those who actually make the important decisions. This selection of targets is assisted by the information about decision makers and industry segmentation, presented in Chapters 2 and 3, respectively.

In this chapter the importance of information pathways is examined by exploring the complex interactions involved in technology diffusion. Options for saving energy that are technically proven and that are aesthetically pleasing and that are projected to become available at lower cost can take a very long time to diffuse into the market. Shama (1983) indicates that the process can only be understood by a combined engineering, economic and behavioral perspective. The engineering and economic attractiveness of an energy saving concept has to be favorable, but that is not enough. Shama indicates that the use of energy conservation concepts may be speeded up by applying the concepts of technology diffusion. The concepts of technology diffusion provide illumination of the reason that technology can take so long to find application. The technology diffusion concepts are explored and are applied to the RU process in the following paragraphs.

The information pathways and the environment in which they operate appear to be even more important than the content or form of communication in the buildings industry. In this chapter we first examine the complex interactions in the decision environment which make the pathway so important. Subsequently, we briefly examine the broad spectrum of transfer mechanisms (pathways, content, and form) available for use in the building system environment.

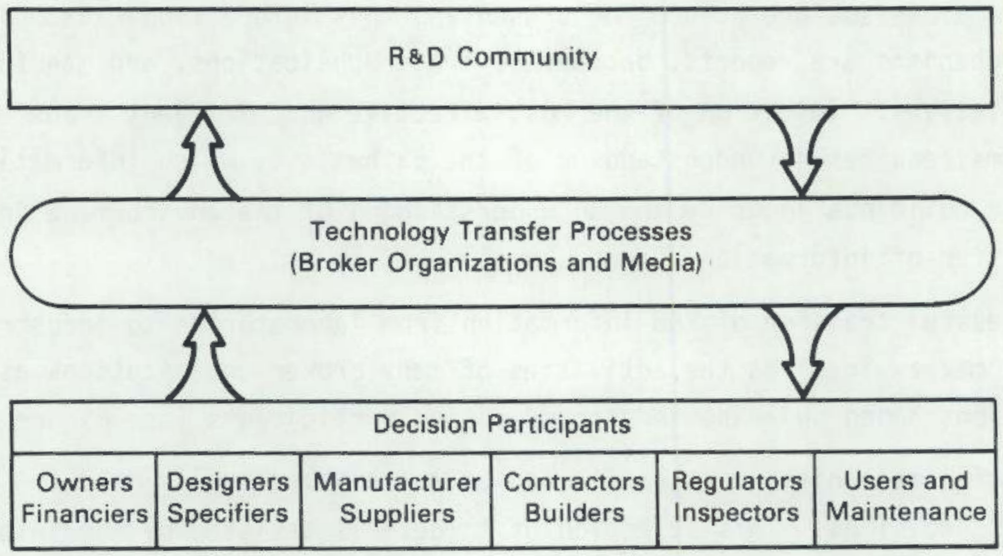

FIGURE 4.1. The Research Utilization Process

4.2. THE DECISION ENVIRONMENT

4.2.1 The Individual Decision Process

All significant decisions involve individual actions, but the adoption of a new concept may involve a number of participants. Each of these participants move through a series of stages (Rogers 1962):

- Awareness
- Interest
- Evaluation
- Trial
- Adoption.

The most effective way of communicating information about a new technology changes as decision makers pass through these various stages. During the awareness stage, impersonal forms of communication, such as journals and books, appear to be the most effective. As decision makers pass to the evaluation stage, more personal communications, such as peer contacts, become more effective. In other words, it becomes a people to people process! In addition, decision makers tend to place more confidence in information that comes from more than one independent source.

4.2.2 Categories of Decision Makers

Rogers (1962) provides a categorization scheme that classifies decision makers as innovators, early adopters, early majority, late majority, and laggards (Figure 4.2). Innovators and early adopters are important participants in technology diffusion. These two groups are the first to try a technology, and their use of technology usually results in acceptance by the subsequent groups of adopters.

The primary differences between innovators and early adopters are the following: 1) innovators accept more immediate risk for potential longer term benefits; and 2) innovators stress both monetary and non-monetary benefits, while early adopters accept or reject a new technology on the basis of normal market factors. Our investigation indicates that these two groups are

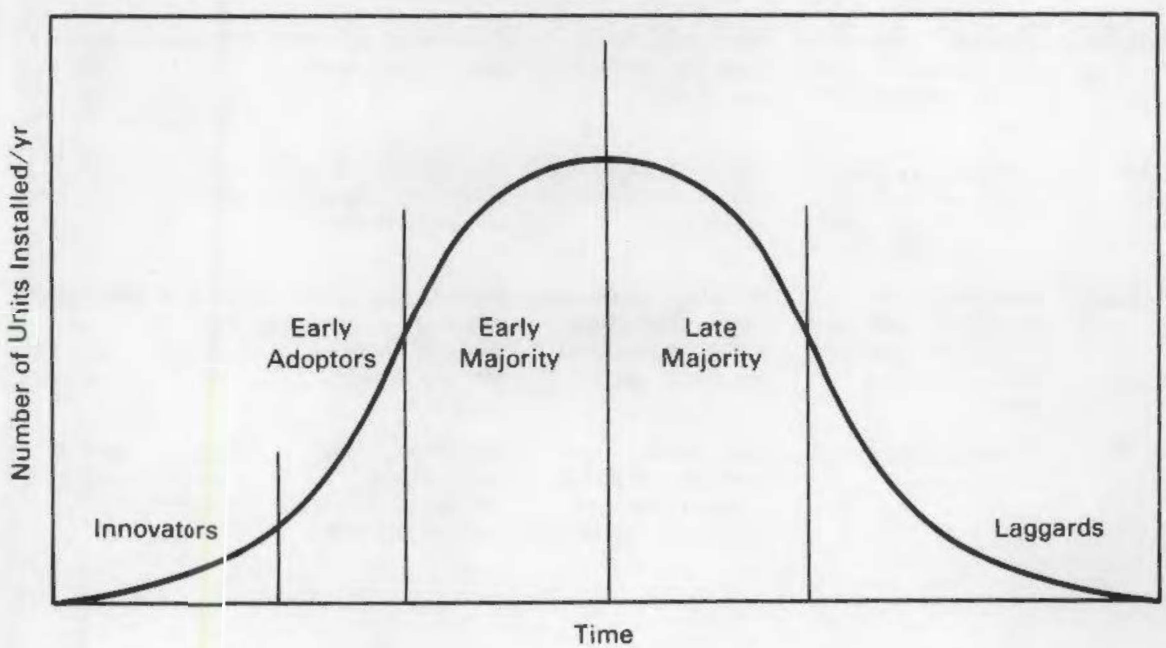

FIGURE 4.2. Characteristic Groups of Technology Adopters

as important in the building industry as they are in other industries we have examined. Innovators are willing to take much greater risks now for the potential of a future payoff. Early adopters, on the other hand, expect to see an immediate return for participation.

Since these two groups appear to operate from different motivations, it is logical to assume that they may require different transfer mechanisms and even different channels for those mechanisms. For example, innovators tend to rely more on impersonal communications (publications, for instance) than subsequent categories of adopters, who rely more on personal communications with trusted adopter peers. Innovators also use a greater variety of information sources than do later adopters, who are less willing to take risks (see Table 4.1).

TABLE 4.1. Characteristics of the Adopter Groups (from Rogers 1962, p. 185)

Adopter Category	Salient Values	Personal Characteristics	Communication Behavior	Social Relationships
Innovators	"Venturesome", willing to accept risks	Youngest age; highest social status; largest and most specialized operations; wealthy	Closest contact with scientific information sources; interaction with other innovators, relatively greatest use of impersonal sources	Some opinion leadership, very cosmopolite
Early adopters	"Respect", regarded by many others in the social system as a role-model	High social status; large and specialized operations	Greatest contact with local change agents	Greatest opinion leadership of any category in most social systems; very localite
Early majority	"Deliberate", willing to consider innovations only after peers have adopted	Above average-social status; average-sized operation	Considerable contact with change agents and early adopters	Some opinion leadership
Late majority	"Skeptical", overwhelming pressure from peers needed before adoption occurs	Below average social status; small operation; little specialization; small income	Secure ideas from peers who are mainly late majority or early majority; less use mass media	Little opinion leadership
Laggards	"Tradition", oriented to the past	Little specialization; lowest social status; smallest operation; lowest income; oldest	Neighbors, friends, and relatives with similar values are main information source	Very little opinion leadership; semi-isolates

4.2.3 Importance of Interactions Among Decision Participants

Strong interactions among the groups making the key decisions in the building industry influence each decision. Broker organizations and R&D information sources are also important in influencing those decisions as the groups of participants move through the stages of innovation.

Large scale application of energy saving technology will not occur until there are owners that desire the technology, financiers that will supply the money, architects/engineers that will risk their professional reputations, manufacturers that will invest in mass production facilities and in nationwide distribution, contractors that will warranty their installation, compliance and inspection personnel that understand and approve the new approach, building users that want the technology, and maintenance men that can keep the equipment working. However, the owners will not approve the technology until they are aware that occupants desire the concept and that more than one manufacturer can supply it.

The decision participants exercise veto powers over the selection of energy conservation technology. The sophisticated architect does not say, "I won't." What the architect does say is, "If you really want me to, I can design it for you, but it will be a lot more expensive." The manufacturer says, "I can make it for you, but it will cost." The distributor says, "I can get it for you, but it will take an extra 3 months." The contractor says, "If you insist, I can put it in, but I hear that they don't hold up, so I cannot give you any warranty." The individual with final approval does listen to his peers and to other decision participants, giving them effective de facto veto power, even though they may not actually sign concurrences. Trusted sources such as peers and industry participants may be more important in the decision process than the exact form or content of technology transfer communications.

4.2.4 Technology Diffusion in the Buildings Industry

The technology diffusion process frequently takes longer in the buildings industry than in other "fast moving" industries. Speeding up this process requires an understanding of the steps involved in the adoption of a new technology.

Many new technologies appear to have great promise at first as a few enthusiastic innovators express optimism. But the technology frequently encounters more difficulty than expected and quantity buyers may stay away in large numbers. This is a feedback (market signal) to industry or to R&D organizations that the technology is not "ready" (see Figure 4.3). In the electronics industry it has in some instances taken 15 to 20 years for technology to penetrate a market. It is quite normal in this high-technology industry for new technology to go through one or more false starts before it is finally accepted (see Figure 4.4, Murray 1981).

The electronics industry might be expected to accept technology more quickly than the buildings industry because 1) one person can frequently make the decision to purchase; and 2) the industry is more compact, and fewer institutions are involved in brokering and regulating the use of new technology.

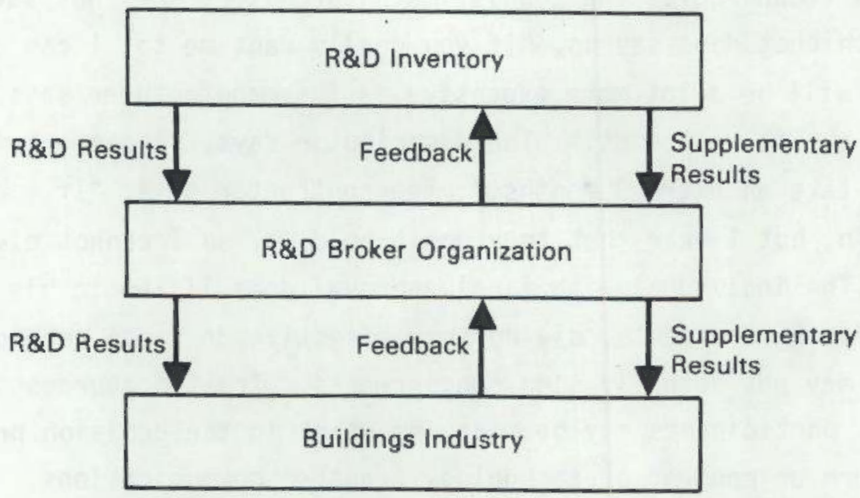

FIGURE 4.3. Transfer Involving Recycle

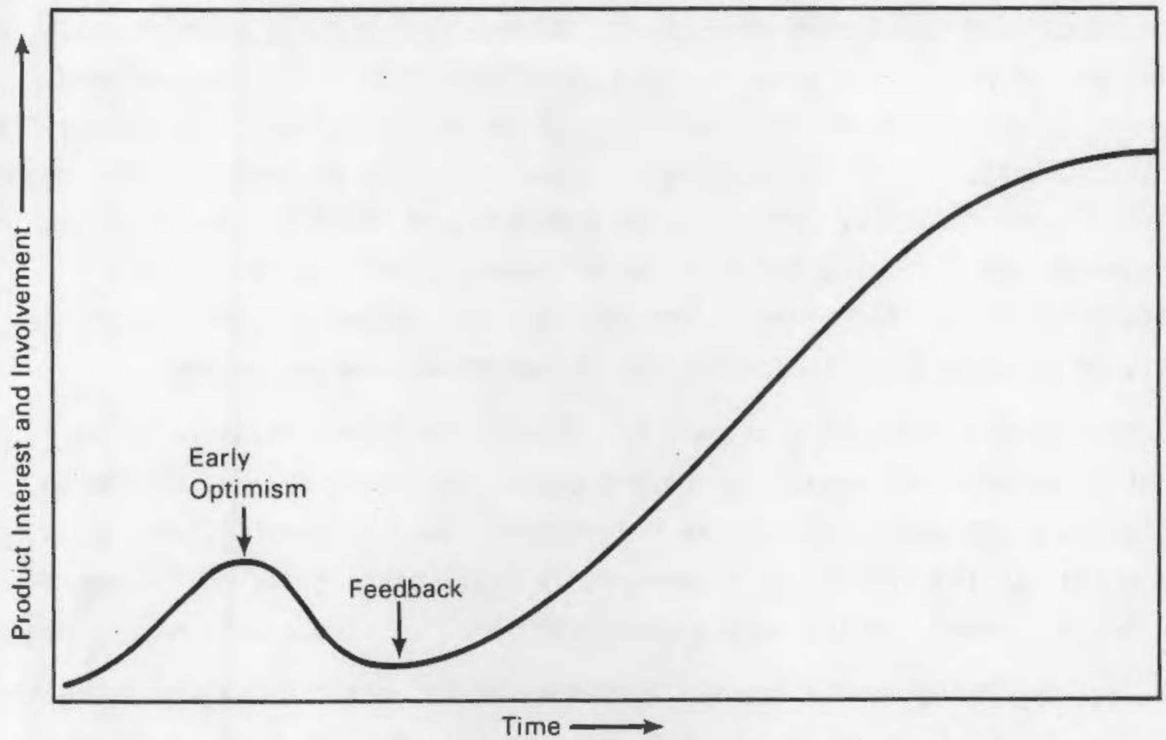

FIGURE 4.4. Typical Swings in Technology Interest Level

4.2.5 Why Innovators are Crucial to RU in Buildings

New technology must be used by innovators in large enough volume to reduce the perceived costs and risks, and to demonstrate the benefits of the technology to the early adopters. In other words, new products and technologies must compete with established technologies, which have already progressed along a "learning curve."

The technology diffusion efforts of interest to this study must go through the innovator phase of market acceptance to achieve perceived costs/benefits sufficient for acceptance by each of the early adopter participants. Technology can not skip the innovators and go directly to early adopters unless there are no cost penalties (including risks), and the performance of the new technology is significantly better than that of the existing products. These situations are rare, and in any case, they require little or no assistance from technology transfer efforts to find their way into the marketplace.

Learning curves show the relationship between the unit cost of a good or a technology, and cumulative production. As the market for a product grows, the unit cost of production tends to fall as economies of scale are achieved. However, these curves neglect the transaction and installation costs involved in the purchase of a new technology. These costs can be extremely important in the buildings industry. Distribution channels are difficult to establish because of the diversity and geographic dispersion of the participants. Installation costs for a new technology can be tremendous, and maintenance costs of an unfamiliar technology can outweigh any energy savings.

Many technologies fail to make the transition from innovators to early adopters because not enough innovators participate in the early market to reduce both the manufacturing and transaction costs to competitive levels. In the buildings industry, this is especially true, since teams of innovative owners, designers, manufacturers who would agree to participate may be needed.

Ideally, large initial costs, including risks, might be shared among the decision makers (innovators), who might gain the benefits over a period of time. This is unlikely to occur because of the diffuse nature of the buildings industry. A disproportionate share of the costs would probably be borne by a few of the decision makers (perhaps the owner or the speculator).

When a sufficient number of innovators cannot be located, it may be necessary to find ways to motivate some early adopters to act like innovators.

A major factor affecting the difficulty to be encountered by a new technology is the number of decision makers perceiving large risks. The technology which can be manufactured on existing machinery, distributed through normal supply channels, and finally "transparent" to the user (i.e., does not appear different or require life style changes) will be accepted much more readily than technology that requires major changes in one or more of these factors. A 10% improvement may be adequate (when it is available from fully trusted sources) for the lower risk situation, whereas a 100% improvement may not be enough to overcome the requirements for new production machinery, new distribution and new appearance, and life style changes.

4.2.6 Decision Environment for Innovation Participants

There are important differences in the decision environment for the groups of participants identified in chapter 3 during the innovator phase of a product's life. The following paragraphs review the decision environment of the various groups participating in the acceptance or rejection of new building technology.

Building Owners and Financiers

The complexity of the technology transfer process in the buildings industry causes most of the changes that take place to come very slowly. For this reason, other market areas are likely to appeal more to the innovative owner/financier. Venture capitalists, however, may be able to give some indication of what motivates owners/financiers in the building industry. Cambridge Research & Development Group provides a brief summary of what they look for in new technology:

1. Does someone really need the product? Not might like or might buy, but really need it?
2. Does a market know that it needs a product? Even though it may be good for a company, if it has to spend money to convince people they need the product, look for a better idea.
3. Does the market perceive an immediate need for the product? Not six months or a year from now, but an immediate need.
4. Does the consumer who perceives the need also control the purchase decision? Can he or she come up with the money?
5. Can it be manufactured for 5% or 10% of the selling price? If a product is really innovative, the company should be able to make a lot of money marketing it. Forget the whole matter if it doesn't promise to earn at least 15¢ after-tax profit on each $1 of sales.
6. Can patents be protected? Concentrate on a field where patents are respected.
7. Is there a pool of buyers for the product at the price that produces profit today? The ability to sell a product eventually for $500 won't help get the company off the ground with a $1,000 product unless there are enough buyers right now at $1,000 to finance future growth.

8. Will product success strain the company's financial, manufacturing, or marketing resources? Many companies evolve elaborate contingency plans in case of failure but are unprepared for success.
9. Is the environment noncompetitive? If yes, the product's chances for success are improved, especially if the company gets an edge on the market before similar products arrive.

Financially affluent owners who intend to occupy the building themselves may see the new technology as providing unique non-monetary benefits such as improving quality of life and productivity and thus, may provide an alternative to meeting the financially oriented needs of the investor.

Targeting innovators in the owner/financier group is a challenge because those who can afford the higher costs of the initial investment in a new concept probably can afford subsequent fuel costs even if they increase drastically. From our discussions with industry, we have come to believe that investor owners are less likely to be a good source group for the needed innovators than are affluent resident owners. This owner/occupier market segment may sometimes be more interested in the aesthetic and functional potential of energy-saving concepts than in the actual amount of energy saved. For example, passive solar concepts can, when properly implemented, add charm. The ambience of an atrium can be enhanced by the proper use of natural light. Selling building owners and financiers on saving energy may be even easier when the collateral benefits, such as enhanced appearance and ambience, are stressed.

Designers and Specifiers

There are powerful forces which may keep architects from actually pushing new building technology. Established architects have reputations to guard. The better established they are, the busier they are and the more substantial are their investments in repeating former success patterns. These patterns may have been very innovative in the past. In addition, they may simply be too busy with more urgent matters. A new architect, on the other hand, has no reputation to uphold, and may, in fact, gain highly valuable recognition from being "different."

Sweet's file is highly regarded by designers and specifiers as a source of information on building components and construction materials. Unfortunately, Sweets' file is primarily filled with information on established products. Our investigation reveals that product brochures supplied by sales personnel are also a highly regarded source of information to designers and specifiers. New technology is almost by definition that technology which has not been put into products and quality brochures by manufacturers and suppliers. Also, publications that emphasize new technologies tend to be viewed as less credible. Thus, Sweet's may not provide much information on "innovations" or R&D results. On the other hand, if the information can be included in the regular sections of Sweet's, it may be highly regarded and trusted.

The Federal R&D reports (including those residing in the National Technical Information Service system) are not frequently accessed by this group.

Manufacturers and Suppliers

Manufacturers and suppliers are vigorously pursuing new products and innovations that can be built on existing machinery, for less money, handled by existing distribution channels, and that offer significant benefits to the consumer without requiring life style changes. This group frequently reviews a new technology using the nine questions listed earlier in the Owner/Financier section.

Several studies have reported that smaller firms tend to be more innovative than larger firms. Many large firms operated by professional managers are not perceived as being innovative. The half-life of the general manager tends to be rather short--perhaps a couple of years. If the manager is good, he or she will be promoted; if not, a replacement will be found on the basis of what happens this year. It might be possible to malign large firms for their lack of an innovative climate. Actually, many large firms, like General Electric, have so many low risk investment opportunities that they cannot begin to afford to follow up all of the more innovative ideas that come to their attention.

It is more important to go with a company that understands the market you wish to penetrate than it is to emphasize technical capability alone. It may be easier to acquire technical talent from government laboratories, for instance, than to acquire knowledge of customer mores and understanding of their needs.

Manufacturers/suppliers may participate in the innovator phase to enhance their image as leaders in bringing out the newest technology as well as in being in on the "ground floor" in a growth industry.

Contractors and Builders

Contractors and builders have a very large potential for vetoing new technology. They usually are not keen on being innovators and frequently they will try to substitute standard equipment. Frequently they succeed. Technology transfer efforts should plan to neutralize this potential veto by:

- Spending R&D money on reliability of the concept, not just on the concept itself. When the electrical contractor gets a call in the middle of the night from an irate customer on a fixed income, you can be certain that he or she will fight any further installation of the high technology thermostat which caused the call.
- Make certain that early test installations are well maintained and firmly decommissioned. R&D reports with their technical honesty tend to frighten the contractor/builder by discussing all the problems encountered with early experimental units.

Federal programs to train installers and to pay for the maintenance and inspection of early installation appear to be very important. If federal officials have personally requested industry participation in early installations, it is very important for the equipment to perform flawlessly.

Regulators and Inspectors

Regulators and inspectors have little to gain and much to lose by allowing new technology to be tried by innovators. Usually, the best way to proceed is to make them early participants in the planning of the project. They are rarely hostile to new technology and can help in getting variances through the system. They are more likely to do this if they are brought on board early.

These early contacts should be made by the architect or builder, who would normally be calling in the inspector to approve the work. The personal touch is all important here. Model codes and actual code changes are useful but the problem is that the period when they are most needed is also the period in which the technology is so new that the codes are not yet available.

Building Users and Maintenance Personnel

Building users and maintenance personnel can be very creative in disabling energy saving apparatus. New equipment that requires extensive maintenance probably will not get much attention in many installations. It is preferable to design maintenance out of the product. The alternative is that reports will soon filter back from the early installations such as "those new thermostats don't work."

Early installations are likely to receive uniformly good reports at first, but the truth begins to come out as first enthusiasm fades. Poor design/ installation causes negative feedback, which will be carried back to the other decision participants.

Users who are not owners have only indirect input into the decision process. Investor owners will sometimes give serious consideration to energy saving concepts requested by very reliable tenants signing long-term leases.

Damage prevention and control is the best strategy for building users and maintenance groups.

4.2.7 Summary of Strategies to Deal With the Decision Environment

Keys to transferring technology in the buildings sector are summarized below.

- Parallel "media blitzes" in widely read journals can produce the first stage of the acceptance process (awareness) but cannot replace the more personal influences, such as favorable impressions provided by associates in the building trades during subsequent stages of the acceptance process.
- Ideally a team of innovators from various decision groups needs to be involved in getting a new concept into a building project, but where innovators cannot be located in sufficient quantity, it may be necessary to convert some "early adopters" into "innovators."

- Technology transfer strategy should provide for facilitating and speeding up communication between R&D and industry.
- Ideally, transfer efforts should target innovators rather than early adopters unless risks to all of the key decision participants are minimal.
- Transfer mechanisms should be designed to either lower the perceived risk and costs or increase the perceived benefits to innovators.
- One possible way to reduce the risks for each participant is to promote the sharing of risks by the various groups of decision makers through the use of shared savings contracts.
- The innovators in the groups of decision oarticipants have motivations different from early adopters, early majority, late majority, and laggards (reputation drives some, while being first drives other innovators).
- Different mechanisms may be required for the different groups of participants. Young architects, for instance, might value high visibility awards such as having designed the "energy saving house of the year."
- Trusted pathways for technology information (different for the various decision participants) appear to be more important than the form or content of the communication.
- Damage prevention and control (preventing negative occurrences and impressions) is just as important as getting "a good press" for new technology.

4.3 MEDIA AND PATHWAY MECHANISMS

There is no perfect media or transfer mechanism. Instead, there are niches for a variety of mechanisms, with some working better than others in specific situations. The purpose of this section is to provide a method of examining the effectiveness of various mechanisms for transferring research results to the buildings industry.

Common industry practice is to differentiate between institutional advertising, product advertising and specific promotions. This parallels the need, as discussed in the orevious section, for first creating awareness and then adoption.

Also exoressed in the previous section is the need to progress from impersonal to more personal contacts. The adoption of new technology involves a dynamic interaction which has many parallels to selling/buying in industry. The following paragraphs examine the various media mechanisms.

4.3.1. Measures of Effectiveness of Transfer Mechanisms

The effectiveness of transfer mechanisms can be characterized according to several descriptors. The descriptors should allow for the measure of the effectiveness of the transfer mechanisms in accomplishing specific functions. The following descriptors have been selected for this analysis:

Formatting: The format in which information can be used is usually far different from the way in which data are collected and reported in a technical report or journal article. This was highlighted in the 1984 Roundtable on Technology Transfer and Research Utilization (Achenback and Seaton 1985).

Validation: Much of the flood of information available to decision makers is discounted because they do not have the time, facilities, or inclination to verify its readiness for commercial use. For example, government reports are widelv regarded as "theoretical," i.e., not valid for use outside the laboratory.

Accessibilitv: The information readily available at the crucial moment of decision is all that is actually used.

Risk Reduction: Some mechanisms have direct impact on risk and allow potential users to validate the technology without considerable expense.

Involvement: The personal touch can increase the effectiveness of the other functions discussed above.

Feedback: An awareness of industry reactions is vital to the effective utilization of R&D results.

A preliminary discussion of available transfer mechanisms follows using the above descriptors.

4.3.2. Broker Organization Effectiveness

Broker organizations transform and validate technical developments into useful formats and communicate them to industry. There are many broker organizations in the U.S. The effectiveness of technology transfer by these organizations varies widely. This topic is being explored by Oak Ridge National Laboratory in considerable detail. A preliminary discussion follows.

Formatting: Broker organizations vary widely in their capability in this parameter. Those made up of members of the trade/profession they represent may do very well. Those made up of lobbyists (frequently not technically trained) may be less effective.

Validation: Broker organizations can be vital because they publish guides and participate in standards setting. These activities require considerable time to accomplish through committee. This time factor may cause them to be more effective in communicating with early adopters than with innovators.

Accessibility: Guides widely distributed to the membership can be very valuable in influencing decisions.

Risk Reduction: Guides containing "accepted practice" provide considerable legal protection to the practicing professional and tradesman. However, since guides lag new technology they may actually increase the liability of the decision maker who first employs new technology.

Involvement: The degree of involvement depends on the type of broker organization and its context of interests and its geographical distance from the decision maker. Personal contact and interest is even more important than geographical proximity.

Feedback: Broker organizations can provide feedback, but the feedback gets processed and modified on its way. The bluntness of actual industry reactions can be softened by broker organizations and industry needs may be presented through a filter of organizational agenda and needs that can color the feedback messages. Perhaps more serious is the time factor: while feedback may not occur fast enough to assist in the innovator phase, it may be fast enough to expedite the early adopter and subsequent phases.

Broker organizations are very active and may be effective in promoting the building industry. Their effectiveness during the innovator phase (the introduction of new technology) is open to question. Broker organizations are obviously quite effective in making the full transition to widespread market acceptance (by providing ASHRAE guides, for instance). More work needs to be done to determine how they can be more effective in the beginning of the transfer process.

4.3.3 Mechanisms Available for Technology Transfer

A wide variety of mechanisms can be used in technology transfer. The effectiveness of these mechanisms depends on the situation. The effectiveness of each mechanism can only be measured for a specific group of decision makers for a specific situation. However, general trends in effectiveness of generic transfer mechanisms can be reviewed. In Table 4.2 generic mechanisms are reviewed for their effectiveness in formatting, validating, making information accessible, reducing risk, and providing personal involvement and feedback. Conclusions from this generic review should be made with caution. However, it can be said that many mechanisms and broker organizations are needed.

The generic mechanisms listed above include specific mechanisms:

- Involvement of the building industry in R&D
  - Planning
  - Monitoring
  - Evaluation
- Personnel exchanges
  - R&D laboratories and manufacturers
  - R&D laboratories and designers
- Interagency R&D teams
- Limited R&D company partnerships to handle the initial risk of new technology introduction
- Institutional mandates and actions
  - Federal energy performance standards
  - State and local performance standards

TABLE 4.2. A Preliminary Review of Generic Transfer Mechanism Effectiveness

	Formatting	Validation	Accessibility	Risk Reduction	Involvement	Feedback
Involvement of Industry in R&D	Low	Low	Low	Low	High	High
Personnel Exchanges	High	Low	Low	Low	High	Medium
Interagency R&D Teams	Low	Low	Low	Low	Low	Low
Limited R&D Partnerships	Low	Low	Low	High	Low	Low
Institutional Mandates	Low	Low	Low	High	Low	Low
Higher Education	Medium	Medium	Medium	Medium	High	Low
Trade Press	High	Low	Medium	Medium	Low	Low
Product Literature	High	High	High	Medium	Medium	Medium
Radio & TV	High	Low	Low	Low	Low	Low
Electronic Media & Films	High	Medium	Medium	Low	Medium	Low
Trade Shows & Exhibits	High	High	Medium	Medium	High	High
Demonstrations & Model Homes	High	High	*Medium	Medium	High	High
Government Agency Contacts	Low	Low	Low	Low	Low	Low
Industry Colleagues	High	High	High	High	High	High
Industry Representatives	High	Medium	Medium	Medium	High	High

* Depends on location distance from potential user.

- Endorsement and leadership
- Tax incentives

- Higher education
  - Endowed chairs
  - Scholarships
  - Competition
- Trade press
  - Press conferences
  - News releases
  - Design awards
  - Magazine feature articles
  - Refered journal articles
  - Texts, references, topical books
  - Monographs
  - Slide rules, guidelines
  - Fact sheets
- Product literature
  - Brochures
  - Product directories and buyers' guides
- Radio and TV (viewed at air time)
  - Talk shows
  - Award presentations
  - Public service announcements
  - Paid announcements
  - Documentaries
  - Feature shows ("This Old House," e.g.)
- Electronic media and films (viewer control)
  - Video tapes and discs
  - Computer software
  - Online databases
  - Databases on PC media
  - Teleconferences
  - Electronic mail and bulletin boards

- Trade shows and exhibits
  - Cosponsors
  - Booths
  - Technical articles
- Demonstrations and model homes
  - Local
  - Regional
  - National laboratory
- Government agency contacts
  - National laboratories
  - Federal bureaus
  - Extension agents
- Industry colleagues
  - Fellow professionals
  - Construction project associates
- Industrial representatives
  - Sales clerks
  - Local sales representatives
  - Factory representatives

An analysis of media effectiveness for target audiences was carried out by Vonier & Associates (see Table 4.3). This study also rated the various media mechanisms for costliness and difficulty.

Many publications available to members of the buildings industry provide information on new energy-saving technologies. Frequently, these publications are written for segments of the buildings industry, and several of these publications are affiliated with institutes or associations. Appendix C contains lists of building industry publications by region and affiliation.

Numbers reflect degree of costliness and difficulty

Audiences \ Media and Vehicles	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

TABLE 4.3. Media for Target Audiences (provided by Thomas Vonier and Associates, Washington, D.C.)

REFERENCES

Achenbach, P. R., and W. W. Seaton. 1985. Proceedings of Buildings Industry Roundtable on Technology Transfer and Research Utilization. PNL-SA-12995, Pacific Northwest Laboratory, Richland, Washington.

Booz, Allen and Hamilton. 1985. Market Analysis and Program for Use for Energy Conservation Manuals: A Marketing Plan. Booz, Allen and Hamilton, Washington, D.C.

Hotel and Motel Management. August 1984. "Franchising: Expansion Continues Vigorously at All Lodging Market Levels." Hotel and Motel Management.

Murray, L. A. 1981. "The Product Growth Cycle for Electro-Optic Technologies." Electro-Optical Systems Design. pp. 55-61.

Rogers, E. M. 1962. Diffusion of Innovations. The Free Press, New York, New York.

Shama, A. June 1983. "Energy Conservation in U.S. Buildings." In Energy Policy. Butterworth and Company Ltd., London, England.

U.S. Department of Commerce. 1985. 1985 U.S. Industrial Outlook. U.S. Department of Commerce, Washington, D.C.

APPENDIX A

OATA ON SEGMENTS IN CONSTRUCTION CONTRACTING DIVISION

APPENDIX A

DATA ON SEGMENTS IN CONSTRUCTION CONTRACTING DIVISION

CONSTRUCTION CONTRACTING

Construction Industries and Subdividers and Developers
(Construction Industry Summary)

This entry summarizes all other entries for construction and development derived from the 1982 census of construction. Also included in this summary, but not reported elsewhere in this report are water well drilling contractors, wrecking and demolition work contractors, special trade contractors n.e.c., highway and street construction contractors, bridge, tunnel, and elevated highway construction contractors, water, sewer, pipe line, communication and power line construction contractors, and heavy construction contractors.

	1982
Total Number of Establishments	447,887
Total Number of Establishments with 20 or Less Employees	
Percentage of Industry Receipts Accounted for by 4 Largest Firms	
Total Employment	4,361,852
Value of Industry Receipts	$312.8MM
Value Added	$148.1MM
Major Producing States:	

Source: 1982 Census of Construction Industries (prelim.)

General Contractors - Single Family Houses
SIC 1521

Establishments in this industry segment are engaged in the construction of single family houses, rowhouses, and townhouses (including new work, additions, alterations, remodeling, and repair).

	1982
Total Number of Establishments	72,061
Total Number of Establishments with 20 or Less Employees	
Percentage of Industry Receipts Accounted for by 4 Largest Firms	
Total Employment	368,675
Value of Industry Receipts	$22.2MM**
Value Added	$ 8.7MM

** $6.3MM of this is subcontracted out

Major Producing States: CA, TX, FL, PA, OH, IL

Source: 1982 Census of Construction Industries (prelim.)

General Contractors, Multi-Family Residential
SIC 1522

Establishments in this industry are engaged primarily in the construction of apartment buildings, hotels, motels, and dormitories (including new work, additions, alterations, remodeling, and repair).

	1982
Total Number of Establishments	7,570
Total Number of Establishments with 20 or Less Employees	
Percentage of Industry Receipts Accounted for by 4 Largest Firms	
Total Employment	65,5185
Value of Industry Receipts	$8.1MM**
Value Added	$2.0MM

** $4.4MM of this is subcontracted out

Major Producing States: CA, TX, NY, IL

Source: 1982 Census of Construction Industries (prelim.)

General Contractors - Nonresidential Buildings Other Than Industrial Buildings and Warehouses
SIC 1542

Establishments in this industry segment are engaged in the construction of commercial, institutions, religious, and amusement and recreational buildings (including new work, additions, alterations, remodeling, and repair).

	1982
Total Number of Establishments	20,184
Total Number of Establishments with 20 or Less Employees	
Percentage of Industry Receipts Accounted for by 4 Largest Firms	
Total Employment	363,261
Value of Industry Receipts	$50.1MM**
Value Added	$13.4MM

** $27.9MM of this is subcontracted out

Major Producing States: CA, TX, NY, IL, FL

Source: 1982 Census of Construction Industries (prelim.)

General Contractors - Industrial Buildings and Warehouses
SIC 1541

Establishments in this industry segment are engaged in the construction of industrial buildings such as aluminum plants, automobile assembly plants, pharmaceutical manufacturing plants, and commercial warehouses (including new work, additions, alterations, remodeling, and repair).

	1982
Total Number of Establishments	7,406
Total Number of Establishments with 20 or Less Employees	
Percentage of Industry Receipts Accounted for by 4 Largest Firms	
Total Employment	106,822
Value of Industry Receipts	$18.5MM**
Value Added	$ 6.0MM

** $8.9MM of this is subcontracted out

Major Producing States: CA, MI, TX, AL

Source: 1982 Census of Construction Industries (prelim.)

Excavating and Foundation Work Contractors
SIC 1794

Establishments in this industry are engaged in excavation work, foundation work, and digging and loading, in connection with building, heavy, or engineering construction.

	1982
Total Number of Establishments	17,368
Total Number of Establishments with 20 or Less Employees	
Percentage of Industry Receipts Accounted for by 4 Largest Firms	
Total Employment	130,440
Value of Industry Receipts	$7.7MM
Value Added	$5.2MM

Major Producing States: TX, CA, PA, IL, FL, NY, OH

Source: 1982 Census of Construction Industries (prelim.)

Structural Steel Erection Contractors
SIC 1791

Establishments in this industry are engaged in the erection of structural steel, the placing of concrete reinforcement and structural iron work, and the erection of metal storage tanks.

	1982
Total Number of Establishments	3,692
Total Number of Establishments with 20 or Less Employees	
Percentage of Industry Receipts Accounted for by 4 Largest Firms	
Total Employment	63,086
Value of Industry Receipts	$3.6MM
Value Added	$2.4MM

Major Producing States: CA, TX, PA, IL, NY, FL

Source: 1982 Census of Construction Industries (prelim.)

Concrete Work Contractors
SIC 1771

Establishments in this industry are engaged in concrete work and the surfacing of concrete floors, applying seal to concrete or asphalt surfaces, constructing with gunite and stucco, and constructing private driveways and walks of all materials.

	1982
Total Number of Establishments	19,884
Total Number of Establishments with 20 or Less Employees	
Percentage of Industry Receipts Accounted for by 4 Largest Firms	
Total Employment	177,763
Value of Industry Receipts	$9.7MM
Value Added	$5.1MM

Major Producing States: CA, TX, NY, IL, FL, OH

Source: 1982 Census of Construction Industries (prelim.)

Electrical Contractors
SIC

Establishments in this industry are engaged primarily in electrical work at the construction site. Also included are electric heating contractors and establishments engaged in the installation of intercommunication equipment, sound equipment, burglar alarms, fire alarms, and telephones.

	1982
Total Number of Establishments	38,470
Total Number of Establishments with 20 or Less Employees	
Percentage of Industry Receipts Accounted for by 4 Largest Firms	
Total Employment	444,315
Value of Industry Receipts	$25.7MM
Value Added	$15.1MM

Major Producing States: CA, TX, NY, IL, FL, PA

Source: 1982 Census of Construction Industries (prelim.)

Plumbing, Heating (Except Electric), and Air Conditioning Contractors
SIC 1711

Establishments in this industry segment are engaged in plumbing, heating (except electric), or air conditioning work or any combination of these types of work. Sheet metal work combined with any of these types of work is included in this segment, but roofing and sheet metal contractors are classified in industry 1761.

	1982
Total Number of Establishments	59,830
Total Number of Establishments with 20 or Less Employees	
Percentage of Industry Receipts Accounted for by 4 Largest Firms	
Total Employment	510,871
Value of Industry Receipts	$32.6MM
Value Added	$16.9MM

Major Producing States: CA, TX, NY, IL, FL, PA, OH, NJ

Source: 1982 Census of Construction Industries (prelim.)

Plastering, Drywall, Accoustical and Insulation Contractors
SIC 1742

Establishments in this category are engaged in applying plaster, plain or ornamental; the installation of lathing or other appurtenances to receive plaster; or in drywall, accoustical, and building insulation work.

	1982
Total Number of Establishments	15,358
Total Number of Establishments with 20 or Less Employees	
Percentage of Industry Receipts Accounted for by 4 Largest Firms	
Total Employment	209,244
Value of Industry Receipts	$9.9MM
Value Added	$6.0MM

Major Producing States: CA, TX, NY, IL, FL, PA,

Source: 1982 Census of Construction Industries (prelim.)

Carpentering Contractors
SIC 1751

Establishments in this industry are primarily engaged in carpentry work and the installation of prefabricated windows and doors (except revolving doors). Ship joinery contractors are also included in this industry.

	1982
Total Number of Establishments	30,634
Total Number of Establishments with 20 or Less Employees	
Percentage of Industry Receipts Accounted for by 4 Largest Firms	
Total Employment	134,000
Value of Industry Receipts	$5.6MM
Value Added	$3.0MM

Major Producing States: CA, TX, NY, IL, FL, PA, NJ

Source: 1982 Census of Construction Industries (prelim.)

Floor Laying and Other Floorwork Contractors
SIC 1752

Establishments in this industry segment are engaged in laying, scraping, finishing, or refining of parquet and other hardwood flooring. Included are contractors that install asphalt tile, linoleum, and mastic and resilient flooring.

	1982
Total Number of Establishments	6,763
Total Number of Establishments with 20 or Less Employees	
Percentage of Industry Receipts Accounted for by 4 Largest Firms	
Total Employment	32,697
Value of Industry Receipts	$1.8MM
Value Added	$0.9MM

Major Producing States: CA, NY, TX

Source: 1982 Census of Construction Industries (prelim.)

Terrazzo, Tile, Marble, and Mosaic Work Contractors
SIC 1743

Establishments in this industry segment are engaged in setting and installing ceramic tile, marble, and mosaic, and in mixing marble particles and cement to make terrazzo at the site of construction. Included are contractors engaged in fresco work and metel work.

	1982
Total Number of Establishments	3,860
Total Number of Establishments with 20 or Less Employees	
Percentage of Industry Receipts Accounted for by 4 Largest Firms	
Total Employment	25,219
Value of Industry Receipts	$1.2MM
Value Added	$0.7MM

Major Producing States: CA, TX, FL

Source: 1982 Census of Construction Industries (prelim.)

Masonry, Stone Setting and Other Stonework Contractors
SIC 1741

Establishments in this industry segment are engaged in masonry work, stone setting, and other stonework. Included are boiler setting contractors, bricklaying contractors, exterior marble contractors, and tuck pointing contractors.

	1982
Total Number of Establishments	20,057
Total Number of Establishments with 20 or Less Employees	
Percentage of Industry Receipts Accounted for by 4 Largest Firms	
Total Employment	120,273
Value of Industry Receipts	$4.3MM
Value Added	$2.7MM

Major Producing States: NY, TX, CA, PA, IL, FL

Source: 1982 Census of Construction Industries (prelim.)

Glass and Glazing Work Contractors
SIC 1793

Establishments in this industry are primarily engaged in glass and glazing work in connection with, but not limited to, building construction.

	1982
Total Number of Establishments	3,864
Total Number of Establishments with 20 or Less Employees	
Percentage of Industry Receipts Accounted for by 4 Largest Firms	
Total Employment	36,517
Value of Industry Receipts	$2.5MM
Value Added	$1.3MM

Major Producing States: CA, TX, NY, PA, FL

Source: 1982 Census of Construction Industries (prelim.)

Painting, Paper Hanging, and Decorating Contractors
SIC 1721

Establishments in this industry segment are engaged in interior and exterior painting (except roofs), paper hanging, and decorating.

	1982
Total Number of Establishments	24,880
Total Number of Establishments with 20 or Less Employees	
Percentage of Industry Receipts Accounted for by 4 Largest Firms	
Total Employment	137,142
Value of Industry Receipts	$4.7MM
Value Added	$3.4MM

Major Producing States: CA, TX, NY, PA, FL, IL

Source: 1982 Census of Construction Industries (prelim.)

Installation or Erection of Building Equipment Contractors
SIC 1796

Establishments in this industry are primarily engaged in the installation of building equipment, not elsewhere classified, such as elevators, escalators, pneumatic tube systems, and dust collection equipment.

	1982
Total Number of Establishments	3,753
Total Number of Establishments with 20 or Less Employees	
Percentage of Industry Receipts Accounted for by 4 Largest Firms	
Total Employment	52,641
Value of Industry Receipts	$4.4MM
Value Added	$3.1MM

Major Producing States: CA, TX, NY, PA

Source: 1982 Census of Construction Industries (prelim.)

Roofing and Sheet Metal Work Contractors
SIC 1761

Establishments in this industry segment are engaged in the installation of siding and roofing (including roof spraying, painting, or coating). Also included are contractors engaged in sheet metal work, except that done in connection with plumbing, heating, or air conditioning.

	1982
Total Number of Establishments	21,215
Total Number of Establishments with 20 or Less Employees	
Percentage of Industry Receipts Accounted for by 4 Largest Firms	
Total Employment	191,526
Value of Industry Receipts	$9.8MM
Value Added	$5.5MM

Major Producing States: CA, TX, FL, IL, NY, PA, OH

Source: 1982 Census of Construction Industries (prelim.)

APPENDIX B

DATA ON SEGMENTS IN THE BUILDING MATERIALS AND COMPONENTS MANUFACTURING AND SUPPLY DIVISION

APPENDIX B

DATA ON SEGMENTS IN THE BUILDINGS MATERIALS AND COMPONENTS MANUFACTURING AND SUPPLY DIVISION

Hydraulic Cement
SIC 241

Portland cement accounts for more than 90% of the output of the hydraulic cement industry. Other products include masonry, natural, prepared hydraulic, and lime cements. Usually about 30% of cement output is used for residential construction and 70% is used for nonresidential. Further breakouts according to end use are given in subsequent cement industry segments, which are subdivisions of hydraulic cement.

	1983	1982
Total Number of Establishments	201	201
Total Number of Establishments with 20 or Less Employees	41	41
Percentage of Industry Receipts Accounted for by 4 Largest Firms	24	24
Total Employment	23,000	27,000
Value of Industry Receipts	$3,809MM	$3,960MM
Value Added	$2,020MM	$2,100MM

Major Producing States: TX, CA, PA, MI, MO

Source: U.S. Industrial Outlook, 1983, 1984

Concrete Block and Brick
SIC 3271

About 50% of the output of the concrete block and brick industry is used in residential construction. About 35% of the output goes to nonresidential building, and about 15% goes for other types of construction.

	1983	1982
Total Number of Establishments	1,273*	
Total Number of Establishments with 20 or Less Employees	925*	
Percentage of Industry Receipts Accounted for by 4 Largest Firms	4*	
Total Employment	16,900	16,000
Value of Industry Receipts	$1,576MM	$1,445MM
Value Added	$ 663MM*	

* 1981 data

Major Producing States: PA, CA, MI, OH, TX

Source: U.S. Industrial Outlook, 1982, 1983, 1984

Ready Mixed Concrete
SIC 3273

The ready mixed concrete industry purchases more than 65% of all cement shipped in most years. About 40% to 45% of the output of the ready mixed concrete industry is used in residential construction, about 25% in nonresidential buildings, 8% to 10% in highways and streets, and the remainder in other nonbuilding construction.

	1983	1982
Total Number of Establishments	5,433*	
Total Number of Establishments with 20 or Less Employees	4,076*	
Percentage of Industry Receipts Accounted for by 4 Largest Firms	5*	
Total Employment	85,000	75,000
Value of Industry Receipts	$9,073MM	$8,735MM
Value Added	$3,862MM*	

* 1981 data

Major Producing States: CA, TX, FL, OH, IL

Source: U.S. Industrial Outlook, 1982, 1984

Concrete Products N.E.C.
SIC 3272

The miscellaneous concrete products industry consists of producers of concrete pipe, precast concrete, prestressed concrete, and dry mix concrete. In most years, the residential construction sector purchases only about 15% of the output of this industry, with another 20% purchased by nonresidential construction. The remainder goes to nonbuilding construction like highways and streets.

	1983	1982
Total Number of Establishments	3,916*	
Total Number of Establishments with 20 or Less Employees	3,054*	
Percentage of Industry Receipts Accounted for by 4 Largest Firms	9*	
Total Employment	52,600	53,000
Value of Industry Receipts	$3,830MM	$3,290MM
Value Added	$2,096MM*	

* 1981 data

Major Producing States: CA, TX, FL, OH, IL

Source: U.S. Industrial Outlook, 1982, 1984

Brick and Structural Clay Tile
SIC 3251

Establishments in this industry segment are engaged in the production of bricks and structural clay tile. Bricks are used primarily in residential applications, while clay tile is used in non-residential.

	1983	1982
Total Number of Establishments	352*	
Total Number of Establishments with 20 or Less Employees	90*	
Percentage of Industry Receipts Accounted for by 4 Largest Firms	21*	
Total Employment	13,900	16,000
Value of Industry Receipts	$987MM	$685MM
Value Added	$592*	

* 1977 data or based on 1977 data

Major Producing States: NC, TX, OH, AL, SC

Source: U.S. Industrial Outlook, 1982, 1983, 1984

Vitreous Plumbing Fixtures
SIC 3261

Between 60% and 70% of the industry's output goes to new residential buildings, about 15% to 20% goes to new nonresidential buildings, and the remainder is used for replacements and additions in existing buildings. This industry is experiencing heightened competition from plastics manufacturers.

	1983	1982
Total Number of Establishments	70*	
Total Number of Establishments with 20 or Less Employees	32*	
Percentage of Industry Receipts Accounted for by 4 Largest Firms	62*	
Total Employment	8,000	8,000
Value of Industry Receipts	$613MM	$520MM
Value Added	$360MM*	

* 1981 data

Major Producing States: OH, TX, PA, IN

Source: U.S. Industrial Outlook, 1982, 1984

Metal Plumbing Fixtures
SIC 3431

Between 60% and 70% of the industry's output goes to new residential buildings, about 15% to 20% goes to new nonresidential buildings, and the remainder is used for replacements and additions in existing buildings. This industry is experiencing heightened competition from the plastics industry.

	1983	1982
Total Number of Establishments	101*	
Total Number of Establishments with 20 or Less Employees	64*	
Percentage of Industry Receipts Accounted for by 4 Largest Firms	54*	
Total Employment	6,400	7,000
Value of Industry Receipts	$638MM	$495MM
Value Added	$245MM*	

* 1981 data

Major Producing States: IL, OH, CA, TX, IN

Source: U.S. Industrial Outlook, 1982, 1983, 1984

Plumbing Fixture Fittings and Brass Goods
SIC 3432

About 40% to 45% of the industry output goes to new residential construction, and the same amount goes for replacement parts. The remainder goes into new nonresidential construction work.

	1983	1982
Total Number of Establishments	213*	
Total Number of Establishments with 20 or Less Employees	103*	
Percentage of Industry Receipts Accounted for by 4 Largest Firms	33*	
Total Employment	15,200	20,000
Value of Industry Receipts	$1,655MM	$1,415MM
Value Added	$720MM*	

* 1981 data

Major Producing States: CA, IN, OH, IL, TX

Source: U.S. Industrial Outlook, 1982, 1984

Fabricated Structural Metal
SIC 3441

Fabricated structural metal plants (SIC 3441) convert metal into shapes (primarily steel) by cutting, bending, welding, drilling and other methods. The plants produce columns, joists and trusses. These are used primarily to build frameworks for buildings, bridges, and to a lesser extent, structures like oil drilling rigs. No breakout by end use was identified, so figures for this industry segment are slightly larger than they would be if we were able to consider only structural metals for commercial and residential buildings.

	1983	1982
Total Number of Establishments	2,462*	2,462*
Total Number of Establishments with 20 or Less Employees	1,388*	1,388*
Percentage of Industry Receipts Accounted for by 4 Largest Firms	10%	10%
Total Employment	92,000	104,700
Value of Industry Receipts	$10,300MM	$7,300MM
Value Added	$ 4,750MM	$3,360MM

Major Producing States: TX, PA, CA, LA, IL

* 1977 data

Source: U.S. Industrial Outlook, 1983, 1984

Prefabricated Metal Buildings
SIC 3448

Establishments in this industry segment manufacture metal buildings that can be installed on a particular site. The primary market for these buildings is for non-residential applications less than 150,000 square feet, including warehouses, small offices and restaurants.

	1983	1982
Total Number of Establishments	8,800*	
Total Number of Establishments with 20 or Less Employees		
Percentage of Industry Receipts Accounted for by 4 Largest Firms		
Total Employment	21,000	23,100
Value of Industry Receipts	$2,030MM	$2,100MM
Value Added		

Major Producing States:

* 1981 data

Source: U.S. Industrial Outlook, 1983, 1984

Sheet Metal Work
SIC 3444

Establishments in this industry segment are engaged in manufacturing sheet metal products for the construction industry. Products include roof drainage equipment, soffits and fascia, siding, stove pipe, heating and air conditioning ductwork, awnings, carports, and drainage culverts. Another important market for sheet metal products is air pollution abatement equipment, including air ducting, hoods, pans, conveyor enclosures, ventilating ducts, and dust hoppers.

	1983	1982
Total Number of Establishments		
Total Number of Establishments with 20 or Less Employees		
Percentage of Industry Receipts Accounted for by 4 Largest Firms		
Total Employment	72,100	79,700
Value of Industry Receipts	$6,750MM	$6,700MM
Value Added		
Major Producing States:		

Source: U.S. Industrial Outlook, 1983, 1984

Flat Glass
SIC 3211

This industry segment is engaged in the manufacture of float, plate, tempered and laminated glass primarily for the construction and the automobile industries.

	1983	1982
Total Number of Establishments	62	62
Total Number of Establishments with 20 or Less Employees	30	30
Percentage of Industry Receipts Accounted for by 4 Largest Firms	90	90
Total Employment	15,600	14,500
Value of Industry Receipts	$1,560MM	$1,840MM
Value Added	$ 850MM	$1,016MM

Major Producing States: OH, TN, IL, PA

Source: U.S. Industrial Outlook, 1983, 1984

MATERIALS AND COMPONENTS MANUFACTURING AND SUPPLY

Manufacturing Housing Firms

Total Units Shipped, 1980	221,000
Percentage of Production Units Accounted for by 4 Largest Firms	28
Percentage of Production Units Accounted for by 30 Largest Firms	77
Manufactured Homes as a Percentage of All Housing Units Sold in 1980	29

Source: Nutt-Powell, Thomas E. Manufactured Homes. Auburn House Publishing Company, Boston, Massachussetts, 1982.

Current-carrying Wiring Devices
SIC 3643

	1982
Value of shipments	2,558
Total employment	45.3

Noncurrent-carrying Wiring Devices
SIC 3644

	1982
Value of shipments	2,400
Total employment	26.3

Lighting Fixtures
SIC 3645, 3646, 3648

	1982
Value of shipments	4,040
Total employment	53.0

Sawmills and Planing Mills, General
SIC 2421

	1982
Value of shipments	11,897.1
Total employment	153.1

Hardwood Dimension and Flooring
SIC 2426

	1983
Value of shipments	1,143.3
Total employment	23.0

Particleboard
SIC 2492

	1983
Value of industrial shipments	591
Value added	260
Total employment	4.5
Total number of establishments	63
Percent of industry shipments accounted for by 4 largest companies	48

Major producing states: OR, CA, MI, VA, GA, LA

Source: U.S. Industrial Outlook, 1984

Softwood Veneer and Plywood
SIC 2436

	1983
Value of industry shipments	4,444
Value added	1,511
Total employment	39.1
Total number of establishments	256
Percent of inndustry shipments accounted for by 4 largest companies	38

Major producing states: OR, TX, AK, LA, WA

Source: U.S. Industrial Outlook, 1984

Millwork
SIC 2431

	1983
Value of shipments	6,566.0
Total employment	73.8

Structural Wood Members, NEC
SIC 2439

	1983
Value of shipments	970.2
Total employment	13.4

APPENDIX C

SWEETS CATALOGUE RECIPIENTS

APPENDIX C

SWEETS CATALOGUE RECIPIENTS

CONTRACT INTERIORS MARKET

INDUSTRY SEGMENT	NUMBER OF FIRMS
Interior Design Offices	2,966
Interior Design Departments in Architectural Offices	1,470
Custom Contract Department	617
Corporate Building Departments	644
Federal, State, Municipal Department and Buying Agencies	124
Schools, Libraries, Plan Rooms	157
TOTAL	5,978

HOMEBUILDING AND REMODELING MARKET

INDUSTRY SEGMENT	NUMBER OF FIRMS
Builders and Contractors	8,578
Architectural Offices	1,831
Builders and Contractors Employing Architects	178
Contractor Remodelers	8,174

Remodelers	3,603
Building Material Dealers	2,879
Dealer-Builders	893
Industrialized Building Manufacturers Miscellaneous	274
Federal, State, Municipal Departments and Buying Agencies	18
Libraries, Schools	109
TOTAL	26,538

MECHANICAL ENGINEERING MARKET

INDUSTRY SEGMENT	NUMBER OF FIRMS
Offices Doing Mechanical Engineering	4,213
Engineers on Staff of Public & Private Owners	1,142
Design Construct Engineers	307
Other Engineering	864
Contractors	3,466
Schools	155
TOTAL	10,147

ELECTRICAL ENGINEERING MARKET

INDUSTRY SEGMENT	NUMBER OF FIRMS
Offices Doing Electrical Engineering	3,746
Engineers on Staff of Public and Private Owners	1,231
Design Construct Engineers	306
Other Engineering	1,058

Contractors	3,328
Schools	155
TOTAL	9,824

CIVIL ENGINEERING MARKET

INDUSTRY SEGMENT	NUMBER OF FIRMS
Offices Doing Civil Engineering	6,028
Engineers on Staff of Public and Private Owners	1,501
Design Construct Engineers	310
Other Engineering	585
Contractors	1,254
Schools	155
TOTAL	9,833

GENERAL BUILDING AND RENOVATION MARKET

INDUSTRY SEGMENT	NUMBER OF FIRMS
Architectural Offices	9,484
Architectural and Engineering Offices	2,335
General Contracting Firms Employing Architects	739
Contracting Companies Employing Architects and Engineers	108
Specialized Consulting Firms	79
Building Design Engineers	331
Consulting Engineers	157
Engineering and General Contracting Firms	56
General Contracting Firms	5,116
Construction Management Firms	60

State, Municipal Departments and Buying Agencies	384
Corporate Building Departments	899
Schools, Libraries, Plan Rooms	102
TOTAL	19,850

INDUSTRIAL CONSTRUCTION AND RENOVATION MARKET

INDUSTRY SEGMENT	NUMBER OF FIRMS
Architectural Offices	765
Architectural and Engineering Offices	476
General Contracting Companies Employing Architects and Engineers	44
Design Engineering Offices	951
Corporate Building Departments	15,682
Federal, State, Municipal Departments and Buying Agencies	260
Schools, Libraries, Plan Rooms	220
TOTAL	21,092

APPENDIX D

PUBLICATIONS FOR BUILDINGS INDUSTRY

PUBLICATIONS IN BUILDING RELATED INDUSTRIES

Publication	Targeted Audience	Circulation	Frequency	City	State	Affiliation
ARCHITECTURE						
AIA Journal	Professional Architects	43,000	Monthly	Washington	DC	American Institute of Architects
AUA Newsletter	University Architects	controlled	Quarterly	Lexington	KY	Association of University Architects
Architectural Record	Professional Architects	77,000	Monthly	New York	NY	
CRIT	Architecture Students	30,000	Semiannual	Washington	DC	AIA, Association of Student Chapters
Form & Function		110,000	Quarterly	Chicago	IL	U.S. Gypsum Co.
Historic Preservation		125,000	Bimonthly	Washington	DC	National Trust for Historic Preservation
Progressive Architecture	Professional Architects	72,000	Monthly	Stamford	CT	
BUILDING AND CONSTRUCTION						
American Building Supplies	Trade Publication	34,500	Monthly	Atlanta	GA	
American Roofer and Building Improvement Contractor	Trade Publication	30,000	Monthly	Bolinas	CA	
Builder	Home Builders	135,000	Monthly	Washington	DC	National Association of Home Builders
Builder & Contractor	Contractors	18,500	Monthly	Washington	DC	Associated Builders and Contractors
Building Design and Construction	Trade Publication	63,555	Monthly	Des Plaines	IL	
Building Operating Management	Commercial Builders	65,000	Monthly	Milwaukee	WI	
Building Supply News	Trade Publication	36,568	Monthly	Des Plaines	IL	
Buildings	Construction & Bldg. Mgmt.	33,000	Monthly	Cedar Rapids	IA	
Commercial Remodeling	Remodelers	40,100	Bimonthly	Chicago	IL	
Concrete Construction	Trade Publication	73,000	Monthly	Addison	IL	
Construction Bargaineer	Building Equipment Suppliers	136,000	Semimonthly	St. Paul	MN	
Constuction Contracting	Contractors	58,503	Monthly	Redondo Beach	CA	
Construction Equipment	Equipment Suppliers/Buyers	89,648	13/Year	Des Plaines	IL	
Constructor	Construction Managers	20,000	Monthly	Washington	DC	Associated General Contractors of America
Home Center Magazine	Building Materials	32,000	Monthly	Chicago	IL	
Home Improvement Contractor	Trade Publication	30,000	Monthly	Chicago	IL	

House Beautiful's Building Manual	Home Improvements	175,000	Quarterly	New York	NY	
Insulation Outlook	Professional Insulators	18,000	Monthly	Washington	DC	National Insulation Contractors Association
M H Builder News	Manufactured Home Builders	11,693	6/Year	Chicago	IL	
Manufactured Housing Newsletter	Manufactured Home Builders	750	Semimonthly	Barrington	IL	
Multi Housing News	Apartment House Builders	45,000	Monthly	New York	NY	
Professional Builder and Apartment Business	Apartment House Builders	114,000	Monthly	Des Plaines	IL	
Professional Remodeling	Trade Publication	36,627	11/Year	New York	NY	
Remodeling Contractor	Trade Publication	20,000	Monthly	Hasbrouck Heights	NJ	National Remodelers Association
Shelter	Building Products	25,000	11/Year	Germantown	TN	
Skylines	Building Owners & Managers	5,000	Monthly	Washington	DC	Building Owners and Managers Association International
Specifying Engineer	Trade Publication	37,000	Monthly	Des Plaines	IL	
Weekly Abstract Newsletter: Building Industry Technology	Building Industry	100,000	Weekly	Springfield	VA	National Technical Information Service

ENGINEERING

ASME News	Mechanical Engineers	Unknown	Monthly	New York	NY	American Society of Mechanical Engineers
Civil Engineering	Civil Engineers	90,000	Monthly	New York	NY	American Society of Civil Engineers
Civil Engineering for Practicing & Design Engineers	Civil Engineers	---	Bimonthly	Elmsford	NY	
Design Professional Product Bulletin Directory		Unknown	Quarterly	Barrington	IL	
Engineering News-Record	Engineers	106,000	Weekly	New York	NY	
Journal of Engineering Mechanics	Civil Engineers	4,300	Bimonthly	New York	NY	American Society of Civil Engineers
Journal Of Solar Energy Engineering	Engineers	Unknown	Quarterly	New York	NY	American Society of Mechanical Engineers
Journal of Structural Engineering	Structural Engineers	8,800	Monthly	New York	NY	American Society of Civil Engineers
Journal of Structural Mechanics	Structural Engineers	Unknown	4/Year	New York	NY	
Mechanical Engineering	Mechanical Engineers	80,000	Monthly	New York	NY	American Society of Mechanical Engineers
World Construction	Engineers	30,500	Monthly	New York	NY	Dun & Bradstreet

ORGANIZATIONS IN BUILDING RELATED INDUSTRIES

Organization	Members	City	State	Publications	Frequency
CONSTRUCTION					
Advisory Board on the Built Environment	21	Washington	DC	Newsletter	Quartery
American Building Contractors Association	700	Los Angeles	CA	American Building Contractor	Monthly
American Institute of Constructors	2,000	Oklahoma City	OK	Newsletter	Monthly
				AIC Register	Biennial
Associated Builders and Contractors	16,000	Washington	DC	The Builder and Contractor	Monthly
				Scoop	Bimonthly
				Classified Membership Dir.	Annual
				Safety Manuals	
Associated General Contractors of America	8,500	Washington	DC	National Newsletter	Weekly
				Constructor	Monthly
				Constructor Annual Roster	Annual
				National Associate Member	Annual
				Manuals, Guides, Etc.	
Associated Specialty Contractors	25,000	Washington	DC	None	
Association of the Wall and Ceiling Industries	800	Washington	DC	The Bulletin	Tri-Weekly
				Construction Dimensions Magazine	Monthly
				Who's Who in the Wall and Ceiling Industry	Annual
				Buyers Guide for the Wall and Ceiling Industry	
Construction Specifications Institute	16,000	Washington	DC	The Specifier	Monthly
				Membership Dir.	Annual
Electrical Institute Study Board	3,000	Chicago	IL	Conduit	Quarterly
Foundation of the Wall and Ceiling Industry	100	Washington	DC	Foundation Updates	Monthly
Independent Electrical Contractors	485	Washington	DC	News Circuit	Monthly
				Membership Directory	Annual
Insulation Contractors Association of America	200	Washington	DC	Bulletins	18-20/year
				ICAA News	Monthly
				Directory	Semiannual
				Brochures	
Mason Contractor Association of America	1,500	Oakbrook Terrace	IL	Newsletter	Semimonthly
				Masonry	11/Year
				Directory	Annual
Mechanical Contractors Association of America	1,700	Washington	DC	Mechanical Contractor and Reporter	Monthly
				Membership Dir.	Annual
				Management and Training Aids	

National Association of Home Builders	123,000	Washington	DC	Builder Newsletter Builder Magazine Economic New Notes Library Bulletin Homes and Homebuilding Booklets, Manuals, Etc.	Weekly Monthly Monthly Monthly Annual
National Association of Plumbing-Heating-Cooling	6,300	Washington	DC	Times	Monthly
National Association of Women in Construction	9,000	Ft. Worth	TX	Image	Monthly
National Electrical Contractors Association	6,200	Bethesda	MD	Newsletter Electrical Contractor Magazine Electro Fact File Total Energy Mgmt. Series NECA Standards	Weekly Monthly Monthly
National Institute of Building Sciences	800	Washington	DC	Building Science Newsletter Technical Publications	Monthly
National Insulation Contractors Association	500	Washington	DC	Insulation Outlook Insulator Labor Report Directory Thermal Insulation Manual & Heat Transfer	Monthly Monthly Bimonthly Annual
National Roofing Constructors Association	2,200	Chicago	IL	The Roofing Spec. Action Information Directory	8/Year 5/Year Annual
BUILDING INDUSTRIES					
Building Owners and Managers Association International	500	Washington	DC	Skylines Society of Real Property Administrators Occupancy Survey of Office Buildings Annual Membership and Committee Directory Convention Directory Income and Cost Analysis	Monthly Quarterly Semiannual Annual Annual
Home Manufacturers Council of NAHB	196	Washington	DC	Housing America Guide to Manufactured Homes Technical and Legislative Bulletins	Monthly Annual
National Building Material Distributers Assoc.	680	Chicago	IL	News & Views Membership Surveys Membership Roster Audio/Visual Cartridges and Monograms	Monthly Semiannual Annual
National Fenestration Council	23	Topeka	KS	News from NFC Roster	Quarterly Annual
Thermal Insulation Manufacturers Association	20	Mt. Kisco	NY	None	

ARCHITECTURE

American Institute of Architecture	37,000	Washington	DC	Memo	Semimonthly
				In Brief	Monthly
				Journal	Monthly
				Firm Directory	Annual
				Membership Directory	Annual
				Misc. Documents	
American Institute of Building Designers	800	Sacramento	CA	Professional Designers Newsletter	Quarterly
				Roster of Members	Annual
				Bulletins, Handbooks & Manuals	
Association of Collegiate Schools of Architecture	545	Washington	DC	News	Bimonthly
				Journal of Architectural Education	Quarterly
				Proceedings of Annual Meeting	Annual
				Architectural Schools of North America	Biennial
				Life Experiences in Environmental Design	
Association of Student Chapters, AIA	30,000	Washington	DC	CRIT: The Architectural Student Journal	Semimonthly
				Newsletter	7/Year
				Videotapes, Pamphlets, Etc.	
Association of University Architects	100	Lexington	KY	Newsletter	Quarterly
National Institute for Architectural Education	250	New York	NY	Yearbook	Annual
Society of American Registered Architects	1,500	Chicago	IL	Practicing Architect	Quarterly
				News Bulletins, Pamphlets & Directories	

ENGINEERING

American Consulting Engineers Council	3,800	Washington	DC	The Last Word	Weekly
				Newsline	Monthly
				Membership Directory	Annual
American Society of Heating, Refrigeration, and Air-Conditioning Engineers	45,000	Atlanta	GA	Journal	Monthly
				Handbook	Annual
				Transaction	Annual
				Membership Roster	Biennial

MANUFACTURED HOUSING

Coordinating Council on Manufactured Housing Finance	12	Washington	DC	None	
Manufactured Housing Institute	485	Arlington	VA	Newsletter	Weekly
				Buyers Guide	Annual
				Membership Directory	Annual
				Quick Facts	Annual
Manufactured Housing Task Force	108	Reston	VA	Newsletters	

National Manufactured Housing Federation	26	Washington	DC	Federation Focus Federal Register Digest	Biweekly Bimonthly
National Manufactured Housing Finance Association	22	Washington	DC	None	
AUTOMATIC CONTROL					
American Automatic Control Council	8	Research Triangle Park	NC	None	
International Federation of Automatic Control	42	Austria		Automatica Newsletter Proceedings	Bimonthly
Numerical Control Society	4,000	Glenview	IL	Journal NC Scene Conference Proceedings	Bimonthly Bimonthly Annual
OTHER					
Air-Conditioning and Refrigeration Institute	160	Arlington	VA	Koldfax Legislative Scorecard State Government Affairs Data Book Applied Equipment Directory Unitary Equipment Directory Transport Directory Water Coolers Directory	Monthly Monthly Monthly Semiannual Semiannual Annual Annual
Hydronics Institute	75	Berkeley Heights	NJ	Builders Choice Builders Log HVAC Data File Hydronics Marketing School Heating Facts IBR School Newsletter	3/Year 3/Year 3/Year 3/Year 2/Year Annual
Illuminating Engineering Society of North America	10,000	New York	NY	Lighting Design and Application Journal Lighting Handbook	Monthly Quarterly Quinquennia
International Association of Lighting Designers	----	New York	NY	Newsletter	Monthly
National Association of Electrical Distributors	2,652	Stamford	CT	Electrical Distributor	Monthly
National Electrical Manufacturers Association	550	Washington	DC	News Bulletin Manuals and Guides	Monthly
National Particleboard Association	20	Silver Spring	MD	Technical Bulletins Promotional Material	

REGIONAL PUBLICATIONS IN BUILDING RELATED INDUSTRIES

Publication	Targeted Audience	Circulation	Frequency	City	State	Region
BUILDING AND CONSTRUCTION						
Builder Architect-Contractor Engineer	Builders	3,300	Monthly	Phoenix	AZ	Southwest
Builder Developer West	Apartment Contractors	25,618	Monthly	Anaheim	CA	West Coast/California
Building Construction News	Builders	controlled	Monthly	Cleveland	OH	Northern Ohio
California Builder	Builders	6,000	Monthly	San Francisco	CA	California
California Builder and Engineer	Builders	12,000	Bimonthly	Palo Alto	CA	California
Connecticut Construction	Builders	3,400	Bimonthly	Farmington	CT	Connecticut
Contracting in the Carolinas	Contractors	4,590	Quarterly	Darlington	SC	North and South Carolina
Dixie Contractor	Contractors	8,757	Fortnightly	Decatur	GA	Southeast
Illinois Building News	Building Suppliers/Buyers	1,500	Monthly	Springfield	IL	Illinois
Intermountain Contractor	Contractors	3,000	Weekly	Salt Lake City	UT	Rocky Mountains
Louisiana Contractor	Contractors	6,000	Monthly	Baton Rouge	LA	Louisiana
Michigan Contractor & Builder	Engineers and Builders	3,693	Weekly	Detroit	MI	Michigan
Mid-West Contractor	Contractors	8,333	2/Month	Kansas City	MO	Midwest
New England Construction	Builders	5,168	Fortnightly	Lexington	MA	New England
New Jersey Shore Builders Association Bulletin Board	Builders	2,200	Monthly	Brick Town	NJ	New Jersey Shore
Northwest Construction News Daily/Weekly	Builders	unknown	Daily/Weekly	Seattle	WA	Northwest
Pacific Builder and Engineer	Engineers and Builders	8,900	Semimonthly	Seattle	WA	Pacific Coast/Northwest
Rocky Mountain Construction	Builders	9,712	Fortnightly	Denver	CO	Rocky Mountains
Southern California Heavy Construction	Engineers	5,700	9/Year	Santa Fe Springs	CA	Southern California
Southern Building	Building Codes	5,100	Bimonthly	Birmingham	AL	Southeast
Sun Coast Architect Builder	Architects/Builders	40,300	Monthly	Los Angeles	CA	Pacific Coast
Texas Contractor	Contractors	5,719	Semimonthly	Dallas	TX	Texas
Utah Construction Report	Builders	1,750	Quarterly	Salt Lake City	UT	Utah

West Virginia Construction News	Contractors	1,200	Bimonthly	Charlestown	WV	West Virginia
Western Builder	Engineers and Builders	4,600	Weekly	Milwaukee	WI	Wisconsin, upper Michigan, N. Illinois

ENGINEERING

CIM Construction Journal	Engineers	850	Weekly	Boston	MA	Construction Industries of Massachusetts
Ohio County Engineers' News	Engineers	5,200	Quarterly	Columbus	OH	County Engineers Association of Ohio

DISTRIBUTION

No. of
Copies

OFFSITE

J. Millhone
U.S. Department of Energy
1000 Independence Ave., S.W.
Forrestal Building, GF-231
Washington, D.C. 20585

F. Abel
U.S. Department of Energy
1000 Independence Ave., S.W.
Forrestal Building, GF-231
Washington, D.C. 20585

D. Jones
U.S. Department of Energy
1000 Independence Ave., S.W.
Forrestal Building, GF-231
Washington, D.C. 20585

30 OOE Technical Information
Center

J. Smith
U.S. Department of Energy
1000 Independence Ave., S.W.
Washington, D.C. 20585

20 M. Gorelick
U.S. Department of Energy
1000 Independence Ave., S.W.
Forrestal Building, GF-253
Washington D.C. 20585

T. Kapus
U.S. Oepartment of Energy
1000 Independence Ave., S.W.
Forrestal Building, GF-217
Washington, O.C. 20585

L. Connor
U.S. Department of Energy
1000 Independence Ave., S.W.
Forrestal Building, GF-217
Washington, D.C. 20585

J. Holmes
U.S. Oepartment of Energy
1000 Independence Ave., S.W.
Forrestal Building, 5H-095
Washington, D.C. 20585

K. Haas Smith
7210 Trescott Ave.
Takoma Park, MD 20912

M. Brown
Energy Division
Oak Ridge National Laboratory
P.O. Box X
Oak Ridge, TN 37831

3 T. Vonier
3741 W Street, N.W.
Washington, D.C. 20007

E. Bales
Campbell Hall
School of Architecture
New Jersey Institute of Technology
Newark, NJ 07102

P. Ruch
Sumner Rider & Associates, Inc.
355 Lexington Ave.
New York, NY 10017

B. Seaton
American Society of Heating,
Refrigeration and Air Conditioning
1791 Tullie Circle, N.E.
Atlanta, GA 30329

J. L. Eisenhauer
Battelle Washington Operations
2030 M Street, N.W.
Washington, O.C. 20030

J. C. Franke
Battelle Washington Operations
2030 M Street, N.W.
Washington, O.C. 20030

L. Crumm
Battelle Washington Operations
2030 M Street, N.W.
Washington, D.C. 20030

ONSITE

DOE Richland Office

H. E. Ransom

47 Pacific Northwest Laboratory

R. C. Adams
W. B. Ashton
M. Clement
R. M. Fleischman
D. R. Johnson (30)
B. L. Mohler
S. A. Smith
R. L. Watts
E. J. Westergard
Economics Library (2)
Publishing Coordination (2)
Technical Information (5)