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Energy Codes and the Building Design Process: Opportunities for Improvement

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May 1994

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

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Foreword

This report is one in a series of documents describing research activities in support of the U.S. Department of Energy (DOE) Building Energy Standards Program. The Pacific Northwest Laboratory (PNL) leads the program for DOE.

The goal of the program is to develop and encourage the implementation of performance standards to achieve the maximum practicable energy efficiency in the design of new buildings. Such standards are required of DOE by Title III of the Energy Conservation and Production Act (42 USC 6831 et seq.) as amended by the Energy Policy Act of 1992 (Public Law 102-486).

The program approach to meeting the goal is to initiate and manage individual research and standards and guidelines development efforts that are planned and conducted in cooperation with representatives from throughout the buildings community. Projects under way involve practicing architects and engineers, professional societies and code organizations, industry representatives, and researchers from the private sector and national laboratories. Research results and technical justifications for standards criteria are provided to standards development and model code organizations and to Federal, State, and local jurisdictions as a basis to update their codes and standards. This effort helps to ensure that building standards incorporate the latest research results to achieve maximum energy savings in new buildings, yet remain responsive to the needs of the affected professions, organizations, and jurisdictions. Our efforts also support the implementation, deployment, and use of energy-efficient codes and standards.

This report documents findings from results of a survey that PNL conducted of architects and designers to determine their knowledge and use of energy codes and energy-efficiency information.

Readers with questions, comments, or suggestions about this document or the work it describes are encouraged to contact the author(s), program managers, or project managers.

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Summary

The Energy Policy Act (EPAct), passed by Congress in 1992, requires states to adopt building energy codes for new commercial buildings that meet or exceed the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) and Illuminating Engineers Society of North America (IES) Standard 90.1-1989 by October 24, 1994. In response to EPAct many states will be adopting a state-wide energy code for the first time. Understanding the role of stakeholders in the building design process is key to the successful implementation of these codes.

In 1993, the Pacific Northwest Laboratory (PNL) conducted a survey of architects and designers to determine how much they know about energy codes, to what extent energy-efficiency concerns influence the design process, and how they convey information about energy-efficient designs and products to their clients. Findings of the PNL survey, together with related information from a survey by the American Institute of Architects (AIA) and other reports, are presented in this report. This information may be helpful for state and utility energy program managers and others who will be involved in promoting the adoption and implementation of state energy codes that meet the requirements of EPAct.

Findings

Key findings presented in this report include the following:

- The typical commercial building design and development process involves several key stages that require the specialized efforts of the owner/client, financiers, designers (architects and engineers), code officials, and contractors. Each of these parties can influence the building's energy efficiency, but the greatest potential for cost-effective energy efficiency is found in the early stages of the design process.
- Architects that responded to the 1993 PNL survey believe that developers, contractors, and the general public are only moderately concerned about energy code compliance in buildings. Architects rated themselves as having the highest concern (7.7 on a scale from 1 [little concern] to 10 [very high concern]), followed by code officials who they rated as having an average concern of 6.7.
- The highest potential for energy savings occurs during the building design process. Because architects are typically responsible for coordinating the efforts of others involved in the building design and construction process, it is very important that architects be involved in programs that promote the construction of energy-efficient buildings.
- Architectural firms typically have a small number of employees. In fact, 30% of the members of the American Institute of Architects are sole practitioners and 86% have less than 10 employees. However, large firms (over 20 employees) dominate the industry in terms of billings.

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- Architects get information on energy codes from a variety of sources. The most popular sources include states, local municipalities, the AIA, and trade publications.
  - The majority of architects (60%) said they could use more information on energy codes. Many said they needed more information that is clear, concise, practical, and easy to understand. Suggestions for information formats include increased use of case studies, handbooks, "rules of thumb," checklists, compliance forms and worksheets, code overviews, graphics, and examples of code applicability. Also mentioned were more information on life cycle cost analysis, information on available rebate programs, and energy savings data that could be presented to clients. They also recommended increasing the availability of energy design tools and using a standard format across states that can be easily updated when codes change.
  - Over half of all architectural firms contract with mechanical (66%) or electrical (59%) engineers when designing buildings. These engineers often have significant influence on the energy efficiency of a building.
  - First cost is by far the most important factor used by an architect's client when considering the inclusion of various building components, including energy-efficiency measures. Other factors considered include operating cost, maintenance cost, product availability, and aesthetics.
  - Architects said they provide their clients with building options to improve energy efficiency about 70% of the time, but less than 16% of architects contacted said they *always* present this information.
  - Some of the barriers to energy-efficient design that architects perceive include a lack of information on energy-efficient design practices and tools; the higher initial cost of energy-efficient components which can make them difficult to sell to clients; the limited availability; and the lack of a proven performance record and service support for new energy-efficient technologies, which can introduce additional risk in the project.
  - Utilities that offer conservation programs targeted to the design community can offer a number of "lessons learned" in terms of developing and implementing successful energy-efficient design programs. Lessons learned include 1) the need for program flexibility in terms of building types, sizes, and energy savings; 2) design recognition for those architects participating in the program; 3) design component flexibility (a menu of energy-efficient design options); 4) tactful information dissemination; 5) acceptable incentives; 6) product/equipment delivery; and 7) design community involvement.

Recommendations

From architects' responses to the PNL survey and the AIA survey, we would make the following recommendations to those developing energy-efficiency and energy code implementation programs.

- Involve architects in programs that promote construction of energy-efficient buildings, because of their early involvement in the design process and their coordinating role on the design team.

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- Tailor different programs for architecture firms based on firm size and type of construction activity.
  - Use information sources such as states, local municipalities, AIA, and trade publications to get architects the information they need on energy codes, energy code programs, and energy-efficient building design practices.
  - Provide code implementation information that is clear, concise, practical, and easy to understand.
  - Provide information in a variety of easy-to-use formats including case studies, handbooks, "rules of thumb," checklists, compliance forms and worksheets, code overviews, graphics, and examples of code applicability.
  - Provide information on life cycle cost analyses and energy savings data that architects could present to clients. Providing more information on the benefits and proof of performance of energy-efficient components would make them easier to sell to clients.
  - Make information on energy-conservation rebate programs more widely available.
  - Increase the availability of energy design tools.
  - Use a standard energy code format across states that can be easily updated when codes change.
  - Give architects assistance and incentives to improve the rate at which they provide clients with information about energy-efficient building options.
  - Provide more information on energy-efficient design practices and tools. Increase the availability of new energy-efficient technologies, and service support for these technologies, to lower their risk to designers.
  - Make sure programs are flexible in terms of building type, size, and energy savings.
  - Publicly recognize those architects who participate in the program.
  - Allow for design flexibility, e.g., architects could be given a menu of energy-efficient design options to choose from.
  - Distribute information to architects tactfully without being patronizing.
  - Offer financial incentives for higher participation rates.
  - Work with manufacturers to improve product availability and delivery schedules to increase the use of less common high-efficiency products.
  - Make contacts with the design community by getting involved in professional societies and local organizations.

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Introduction

This report was prepared by the Pacific Northwest Laboratory (PNL) in support of the U.S. Department of Energy (DOE) Building Energy Standards Program. The Energy Policy Act (EPAct), passed by Congress in 1992, requires states to adopt building energy codes for new commercial buildings that meet or exceed the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) and the Illuminating Engineers Society of North America (IES) Standard 90.1-1989 by October 24, 1994. DOE and PNL are assisting states with basic code support, training, and implementation materials to help states meet the requirements of EPAct. Since many states are adopting a state-wide energy code for the first time, there is a need for concise, straightforward information about the building design process and the perceptions of architects and other stakeholders regarding energy efficiency.

This report was prepared to provide information that is useful to state and utility energy program administrators and others involved in the adoption and implementation of state building energy codes to meet the requirements of EPAct. This information, presented in a question and answer format, provides a basic overview of the building design process and the role of key stakeholder groups, discusses elements of successful energy code implementation programs, and details recent findings on building designers' perceptions and use of energy code information and energy-efficient products and components. A general understanding of these factors is important because the involvement and support of the building design community has been found to be a critical factor in promoting the construction of energy-efficient buildings.

Much of the information contained in this report was obtained from two recent surveys: the 1991 American Institute of Architects (AIA) Firm Survey and a survey of architects and building designers conducted in 1993 by PNL. Brief descriptions of these two surveys follow.

1991 American Institute of Architects Firm Survey Report

The AIA, founded in 1857, is a professional society representing over 55,000 architects across the United States. According to AIA, their membership represents over 90% of all architectural firms nationwide. The AIA conducts a survey of its members every 2 years to provide members and the general public with an overview of the architectural industry. The most recent AIA survey, conducted in 1991, was mailed to 15,000 member-owned firms. The 3,100 completed surveys received by AIA represent 2,800 firms providing architectural services in the United States. Topics covered in the survey include revenues, projects, work force, compensation, professional liability, computers, marketing, and industry expectations.

1993 PNL Architect/ Designer Survey

PNL sent surveys to over 2,000 attendees of the 1993 AIA National Convention held in Chicago, Illinois; nearly 300 architects from across the country responded (a response rate of 15%). The survey included several questions about architect practices and perceptions regarding the design process and energy efficiency: Where do architects get information on energy codes and how useful is this information? How concerned are different groups about energy code compliance (architects/designers, developers, code officials, contractors, and the general public)? How often do architects present clients with energy-efficient building upgrades? What factors are considered when specifying or purchasing various building components? What barriers to energy-efficient design do designers face? and What factors would help make building energy code implementation programs more effective?

Questions and Answers

What is the typical building development process like?

Like just about everything else, building projects get started because someone (or a group of someones) believes there is an unmet need. The person responsible for setting the building design and construction process into motion is typically the owner or developer.

Figure 1 provides a general overview of the building design process for the stages of pre-construction, construction, and use. These stages require the specialized efforts of the owner/client, financiers, designers, code officials, and constructors.

Figure 1. The Development Process (Lewis 1991)^(a)

Who gets involved in the design of commercial buildings?

Commercial buildings are designed and built according to a process that involves input from a number of individuals with differing influence on the process. These individuals include architects, engineers, specialized consultants, financiers, design approvers, and customers. End users are also influencers because they ultimately decide on a building's success (or lack thereof) through occupancy rates. Understanding how architects and others on the design team can influence the design of energy-efficient buildings is key to the design of programs that are effective in influencing the design and construction of energy-efficient buildings in this country.

(a) This figure reprinted with permission from *Architect? A Candid Guide to the Profession*, by R.K. Lewis, MIT Press, 1991.

What types of buildings do architects typically design?

Because architects are involved in the design of nearly all commercial building activity in this country, and because one of the architect's primary roles is to coordinate the efforts of all involved in the building design process, they are key to the overall commercial building design process.

According to the 1991 AIA survey of member architectural firms (AIA 1991), the largest source of revenues for these firms is the design of commercial buildings. Figure 2 shows a breakdown of billings by project type for AIA participants in the 1991 AIA survey of member firms. This sort of information is important to planners of energy-efficiency programs since the type of energy design assistance needed by architectural firms varies according to the primary type of project work conducted by that firm. In addition, architects may encounter different barriers to energy-efficient construction depending on the type of building they typically design. Speculative office buildings, for example, are typically built as standard office buildings with little in terms of upgrades so that the building can be easily adapted to the needs of potential tenants.

Figure 2. Sources of Architectural Firms' Revenues by Building Type (AIA 1991)

How large is the typical architectural firm?

According to the 1991 AIA Member Survey, 64% of reported construction activity billings were for new buildings as opposed to building renovations. For some building types, such as multi-family housing, justice, transportation, and cultural buildings, 70% were new construction. The renovation projects architects are most likely to design are health facilities, followed by single-family residences.

Architectural firms vary in size from sole practitioners to firms with large staffs of 20 or more employees. As noted in the AIA survey of member firms, one of the most striking aspects of the architectural services industry is the prevalence of small firms. Of all architectural firms responding to the 1991 AIA survey, 86% reported fewer than 10 full-time staff members, including principals. Figure 3 presents the distribution of firms by firm size.

Figure 3. Distribution of Architectural Firms by Size (AIA 1991)

Large firms, defined by AIA as firms having 20 or more employees, account for just 5% of all firms. These large firms, however, dominate the industry, accounting for 50% of the industry's 1990 billings (AIA 1991). Understanding the role of different sized firms in the marketplace and the type of customers they serve provides useful information for implementing energy-efficient design assistance. As evidenced in Figure 4, large firms provide a significant portion of the total architectural services provided for all types of commercial building design.

Figure 4. Architectural Firms' Share of Total Revenues from Client Type by Firm Size

What is the role of the architect in the building design process?

The architect's fundamental functional and legal responsibility to his/her client is to prepare drawings and specifications accurately depicting what will be constructed, to assist the client in obtaining all required approvals of the project, and to mediate and provide guidance throughout the project (Lewis 1991). Table 1 provides an overview of the five primary stages of architectural services.

Architects typically complete the design of commercial buildings with the specialized assistance of engineering services conducted by structural, mechanical, electrical and civil engineers. A primary responsibility of the architect is to coordinate the efforts of these diverse groups.

Table 1. The Five Phases of Architectural Services (Lewis 1991)

Phase	Architectural Service	Work Product
Phase 1. Schematic Design	Analysis of the owner/client's program, site, and budget, sketch from preliminary design studies, and preliminary estimate of probable construction cost.	• Program diagrams • Function diagrams • Site plans, floor plans, sections, elevations, perspectives, and models in sketch form
Phase 2. Design Development	Further development of the schematic design; definition of basic project systems and materials; project size, dimensions, and architectural character decisions; update estimate.	• More precise plans, sections, elevations and site plan drawings • More realistic perspectives and study models
Phase 3. Plan Specifications	Detailed design of the project, including all engineering design, selection of materials, dimensions, construction assemble details, and appropriate construction notes required to obtain construction bids and building permits.	• Working drawings • Specifications • Bidding information
Phase 4. Bidding/ Negotiation	During or after completion of the construction documents the architect will assist the client in finding, screening, and selecting qualified general contractors to send RFPs, and will assist the client in bid review and in awarding the contract.	• Contractor's bids • Construction contracts • Modified design documents to meet budget
Phase 5. Construction Administration	Represent and/or assist the client in administering the construction contract, including making design changes and site visits, reviewing the contractor's work, requests for payment, selecting colors, checking shop drawings prepared by fabricators, and mediating disputes between contractor and owner.	• Design change documents • Field reports of site visits • Certifications for payment and completion

What role do computers play in the design process?

Eighty percent of architectural firms responding to the 1991 AIA Survey reported that computers are used at their firm. Most firms (72%) use IBM or compatible personal computers (PCs) operating within the DOS environment. Firms that do not have computers are typically the smaller firms, either sole practitioners or firms with two to four employees.

Computers are used in a variety of capacities, the most popular applications being word processing, spreadsheets, specifications, and computer aided design (CAD). Figure 5 shows the percentage of firms that use specific software applications.

Figure 5. Percent of Firms Using Computers for Specific Software Applications (AIA 1991)

The use of CAD within the architecture industry has grown considerably over the past several years, and over half the architectural firms now use CAD for construction drawings and/or conceptual designs. Large firms are more likely than smaller ones to use CAD as a conceptual design tool (AIA 1991). AutoCad is the most popular CAD software program; 53% of the firms with CAD capabilities use this program. Other CAD software programs include Datacad, Versacad, Cadvance, and Arris.

Eight percent of firms responding to the 1991 AIA Member Survey reported using computers for energy analysis, and 3% were considering buying a computer for this purpose. The percentage of firms using computers for energy analysis increased with firm size: 6% of firms with less than five employees used computers for energy analysis compared to 25% of the firms with 20 or more employees.

Where do architects get information on energy codes?

Most (67%) of the 300 architects who responded to the PNL survey said they received energy code information directly from their state. Local municipalities were also commonly mentioned (37%) as a source of this information, as was the AIA (36%). Other sources for energy code information include code consultants (16%), mechanical/electrical engineers (10%), trade/professional publications (8%), and other sources (12%) such as local utilities, ASHRAE, and the Building Officials and Code Administrators International (BOCA). The information sources used by architects are potential information channels that can be used to promote energy-efficient building programs and awareness about updates to energy codes.

Is the current amount and technical content of information received on energy codes sufficient, or could architects use more?

The majority (60%) of the architects who responded said that additional, improved information on energy-efficient building design and building energy codes would be useful. The majority of architects' suggestions for improved information tended to fall into one of four categories: information content, information format, desired topics, and code and standards policy.

Information Content

A couple of central themes related to information content emerged from the data provided by architects; the desire for clear, concise, easy to understand code information, and the need for a central source of energy code information. Figure 6 lists other architects' responses to this question. Architects noted that they often have a difficult time obtaining information on building energy codes and would like to have access to a central source for this information. The most common complaint of current information is that it contains too much legal jargon that is difficult to understand. More clarifications on the specific requirements of the code would be useful.

Information Format

Several suggestions relating to information formats were provided by architects; most involve streamlining information into formats that are short and easy to read. Handbooks and reference books that can incorporate code updates were mentioned frequently. Architects would also like to see more case studies, checklists, code overviews, and more charts and graphics (see Figure 6).

Desired Topics

Architects expressed interest in a number of topics related to building energy codes. Information on life cycle cost determination techniques, recommended modeling techniques, product R-values, and the cost ramifications of different energy-saving building options were mentioned by a number of architects. Architects would also like to see more energy-efficiency-related design tools available. Information on currently available design tools, who makes them, cost, and where to send for further information is also desired.

Building-related topics desired by architects include mechanical systems, building envelope, glazing, lighting, insulation, and solar systems. Information on the energy usages of different building end-uses was mentioned by one architect. Architects also expressed a desire for information on the Clean Air Act, climate maps, and lifestyle influences on the market reception of energy-efficient products.

Architects mentioned that it is often difficult to find information on energy codes, especially for states other than their own. A state-by-state summary of energy codes in a format that could be easily updated on a periodic basis would be very useful. Architects also would like information on utility rebate programs and tax incentives available for energy-efficient building design. One architect said it would be useful to have educational material on the benefits of energy-efficient building design to present to clients. Interpretations of energy codes by regional code officials would also be useful, as would forecasts of future code requirements.

Codes and Standards Policy

Some architects responded that they would like to see a more wholistic approach taken to building energy standards development and implementation. These architects would like information included on the Clean Air Act and other acts that relate to building energy codes, as well as information on societal impacts of building energy codes. Architects also requested background information on the intent of building energy codes. Some architects would like to see one national energy code introduced to prevent confusion.

Technical Content

Architects were also asked about the technical content of information received. Twenty-five percent believe the technical content is just right, 28% believe the content is too basic, and 47% believe the content is too technical. In general, more architects find the information a bit too technical; however, this does not appear to be a significant problem.

REQUESTED TOPICS • State-by-state code summaries • Clean Air Act • Climate maps • Updates of codes • Societal impacts of codes • Lifestyle influence on market reception • Typical wall construction of recent buildings with energy calculations • Lighting standards • Mechanical systems • Energy saving ideas and their cost ramifications • Geographic maps of where (and what) codes exist • Building envelope • Glazing efficiency ratings • Energy usages per building type • Life cycle costs • Forecasts of future code requirements • Cost-payback formulas • Interpretation of codes by regional officials	• Home energy efficiency related to solar • Air exchange rates • Insulation and R-values of products • Recommended modeling techniques • Rebate programs and tax incentives • Manufacturers' products REQUESTED INFORMATION CONTENT • More clear & concise • Easy to understand information on codes • Less legal jargon • More clarifications on code requirements • A central location for code information • Code updates should be sent out on a periodic basis • Information should be more clearly organized • Code information should be easier to find	REQUESTED INFORMATION FORMATS • handbooks • worker samples • updatable reference books • case studies • charts and graphs • bullet point updates • educational materials for clients • less analysis and calculations and more design tools • checklists and code overviews CODES AND STANDARDS RECOMMENDATIONS • There should be one national code to prevent confusion • Take a more wholistic approach to building energy standards (e.g., include information on the Clean Air Act) • Provide background information on the intent of the code

Figure 6. Architects' Requests for Technical Information

States With and Without Energy Codes

Data from the 1993 PNL Architect survey were also analyzed to determine if there were differences between architects' responses to the question about information requests depending on whether the architect was located in a state with a state energy code, a state with energy codes enacted by local jurisdictions, or a state with no state or local energy code. Overall, there were few differences in responses; however, the small number of respondents (7) located in states with no energy code make it difficult to draw conclusions. Of the respondents to

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PNL's survey, 243 are located in states with state energy codes, 33 are located in states with local codes, and 7 respondents are located in states without energy codes.^(a)

The one area where there does appear to be a difference is in architects' satisfaction with the current level of information received on building energy codes. Respondents from states without energy codes were more likely to desire additional information on building energy codes than were respondents from states where local jurisdictions impose building energy codes and states with state-wide energy codes. Since the primary source of information on building energy codes is typically the state, architects from states without energy codes likely receive little information on energy codes unless they request the information from another source.

Clarification on why architects from these states desire additional information on energy codes would be useful. These architects may be responding to a demand by clients for energy-efficient buildings or their own desire to remain informed on energy codes and energy-efficient design practices; or they may design buildings located in states outside of their own that have enacted energy codes.

What is the role of engineers and consultants in the building design process?

When one thinks of building design, architects typically come to mind. This is because it is generally the architect's responsibility to coordinate the unique contributions of all engineering and consulting staff. Architects often rely on the expertise of others, especially when it comes to the design of large-scale buildings.

The 1991 AIA survey of members found that architectural firms pass through an average of 20% of their gross billings to consultants, with the lion's share of these pass-through dollars going to engineers (see Table 2). Twenty-seven percent of the total pass-through dollars go to mechanical engineers, 23% to structural engineers, 19% to electrical engineers, and 6% to civil engineers. Lighting consultants account for 1% of the total pass-through dollars, only 5% of firms responding to the 1991 AIA Member Survey use the services of lighting designers.

(a) The energy code status of each respondents' state was determined by referring to a draft report that PNL prepared for Congress which discussed the status of energy codes in the U.S. in light of the Energy Policy Act of 1992. A small number of respondents were from states where the current status of an energy code could not be verified.

Table 2. Distribution of Architectural Firm Pass-Through Dollars by Consultant Type (AIA 1991)

Consultant	% of Firms Using this Type of Consultant	% of Pass-Through Revenues
Mechanical Engineers	66%	27%
Electrical Engineers	59%	19%
Structural Engineers	73%	23%
Civil Engineers	31%	6%
Other Architects	19%	7%
Landscape Architects	21%	3%
Interior Designers	8%	1%
Surveyors	14%	1%
Soil Geotechnical Consultants	14%	1%
Feasibility Economic Analysts	3%	1%
Lighting Consultants	5%	1%
Acoustical Consultants	6%	1%
Photographers, Renderers, Model Makers	24%	2%
Others	21%	8%

Table 3 shows the types of contributions made by structural, mechanical, electrical, and civil engineers. Other engineering and consulting services used by architects include acoustical engineers, landscape architects, and interior designers. The fact that such a large percentage of pass-through dollars go to mechanical and electrical engineers has important implications for developing programs for energy code implementation. Mechanical engineers are typically in charge of recommending heating, ventilation, and air conditioning (HVAC) products, which can significantly influence the building's energy efficiency. Electrical engineers also can influence a building's energy efficiency by specifying lighting and other electrical systems and products.

Table 3. Contributions of Selected Design Engineers and Consultants to Architectural Projects

Engineering Discipline	Contribution to Design Process
Structural Engineer	Analyzes the structural load-bearing portions of the building including the skeleton or frame, floors, roof, and walls and then specifies sizes, dimensions, material types, and connections for all needed systems and components.
Mechanical Engineer	Analyzes and designs the heating, air-conditioning, ventilating, and plumbing systems.
Electrical Engineer	Analyzes and designs the building's electrical distribution systems.
Civil Engineer	Analyzes and designs the site grading, roadways, storm water systems, sewer systems, bridges, water supply system, and other required utilities.

It is important to note that, since most engineers and consultants act as independent contractors hired by the architect, the architect is legally responsible and financially liable for the work they performed. Despite the potential liability, most architects prefer to take responsibility for the contractors in order to maintain control over the project.

Architects and engineers often develop strong alliances that result in long-term working relationships that endure from one project to the next. Understanding these working relationships and the leverage that these members have on energy-efficient building design can provide important insight into future design assistance programs.

How is the customer (client) involved in the building design process?

Since the customer holds the purse strings, he/she can have a significant influence on the design and construction of the building. This influence, however, depends on the level to which the client wants to be involved in decision making and how closely the client is tied to the building (for example, a client who plans to locate in the building versus a client who will rent out the space). Little has been reported on the criteria used by clients when selecting architects, or where energy efficiency figures into their inherent list of building design criteria. The 1991 study conducted by AIA investigated the distribution of architects' revenues by client type. In 1990, business, industrial, and commercial client types represented the largest share of the respondents' revenues (see Figure 7).

Figure 7. Architectural Firm 1990 Billings by Client Type (AIA 1991)

What factors are important to builders and developers when considering the purchase of various building components, equipment, and materials?

Builders and developers understand that buildings must meet certain building codes which set minimum construction requirements, including energy efficiency. These construction requirements should be recognized for what they are however - a minimum building standard that must be met. If presented with information about building upgrades that can improve the structure's energy-efficiency, and thus reduce the operating costs of the building, the developer or building owner can decide if these building upgrades should be incorporated.

There are several factors that developers/building owners use in deciding whether or not to purchase building energy-efficiency measures. First cost, according to architects who responded to the 1993 PNL architect survey, is by far the most important factor when clients are considering the purchase of various building components. As part of the 1993 PNL architect/designer survey, architects were asked to rate, on a scale from 0 to 10 (0 = no importance, 10 = extremely important) the importance of several factors used by their clients to evaluate the purchase of various building components. Architects gave first cost the highest rating at 9.3, followed by operating cost (7.4), maintenance cost (6.8), product availability (6.0), and aesthetics (5.7) (see Figure 8). One architect said, "developers are primarily interested in first cost unless they will be managing the building. The more sophisticated the client, the more receptive they are to considering investments in building components that reduce maintenance and operating costs." Another architect said "clients talk about other considerations, but initial cost governs decisions 90% of the time."

Other factors mentioned by architects were availability, the existence of tax breaks for energy-efficient building components, life-cycle cost, recycled content of the component, and the compatibility of the component with the rest of the building.

These factors, especially the impact of first cost, are important to consider when designing programs to promote energy efficiency. Energy-efficient products and design specifications are easier for architects to sell to clients if they are consistent with their clients' evaluation criteria.

Figure 8. Importance of Factors Considered When Evaluating the Purchase of Various Building Components (1993 PNL Survey)

What role do financiers play in the building design process?

Once the building need and site are identified, the owner/client has to pull together the expertise and resources needed to transform the idea into a reality. The paramount resource, of course, is money. Funds are needed to cover site acquisition costs, architect and engineering fees, legal fees, project administration costs, market analysis costs, accounting costs, financing fees and interest on debt, marketing and advertising fees, zoning and permit fees, and the actual construction costs associated with labor, materials, and equipment (Lewis 1991). Just 20% to 30% of a project's costs will be covered with equity funds; therefore, building (and building design) activity are directly linked to the availability and cost of funds.

Institutions that make loans for real estate development include commercial banks, savings and loans, insurance companies, pension funds, investment trusts, and some credit unions. These institutions consider a number of criteria when deciding if a project is a good credit risk. Convincing financiers of the advantages of energy-efficient buildings, both in terms of operating costs and marketing (tenant draw), could lead to their more widespread design and construction.

What role do design approvers play in the building design process?

In addition to producing design concepts and drawings, the architect becomes involved in a number of other activities to complete the project. These include obtaining information on building codes and zoning regulations, which place constraints on the allowable use of the building based on the proposed building site. Besides conforming to these codes and regulations, designs must be approved by a number of government agencies, local jurisdictions, and citizens groups who have influence on what their local jurisdiction will approve. All of

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this requires time, patience, persuasion, and sensitivity on the part of the architect. It is not uncommon for cities to have two or three review boards in addition to the building permit department who must approve the plans prior to construction. Since each of these reviewing authorities often has different design criteria, this process may take several iterations.

Design approvers employed by local jurisdictions or counties are responsible for approving building plans for buildings that will be located within their jurisdiction. These design approvers are responsible for making sure that building plans submitted to the local jurisdiction meet the minimum energy-efficiency construction requirements set by the jurisdiction or state.

Coordination between the architect and the design approver is often required when seeking design approval for energy efficiency measures because of the complexities and sensitivities involved with some buildings. This is especially true if the architect has incorporated energy-efficiency measures that are outside a prescriptive path of measures often set by jurisdictions, including measures that are relatively new to the design approver. It is prudent for the architect or design engineer to seek design advice and recommendations from approval bodies to help ensure that the final design meets approval requirements.

What role do contractors play in the building design process?

Over 90% of total building development expenses are associated with the construction contract. In addition, the way the contractor manages the construction process can significantly impact the overall quality and eventual economic and aesthetic outcome of the building. Realizing that the contractor can significantly impact the owner's satisfaction with the overall project, the architect is very concerned about the contractor's success.

Sometimes contractors are selected early in the building design process so they can provide guidance and input on cost-affecting design decisions. Other times they become involved after winning a competitive bidding process based on the building design specifications. Since they are in charge of actually installing all of the energy-efficient equipment and systems specified by the contract, such as heating and air-conditioning, glazing, electrical systems, and lighting fixtures, it is important that they or their subcontractors correctly procure and install the equipment that is specified. Since energy-efficient systems are often more expensive on a first-cost basis, it is tempting for contractors or subcontractors to substitute less costly, less-efficient equipment.

What role do building users play in the building design process?

The primary users of a finished architectural project are those who will be working or living in the final building. Also included as users are those who are impacted by the building including neighbors, customers, or others who have more than occasional contact with the structure.

Although users are not inclined to sit at the table through the design stages of the building, the proactive architect will attempt to determine the users' needs and interests, and incorporate them in the design to the extent possible, to ensure the long-term success of the project for the client.

As consumers, these users have leverage in influencing the attributes of the building. Their needs and desires can be determined to some extent by evaluating the available demand for certain types of buildings at the aggregate level, and by

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What are some of the dynamics of the Design Team?

determining the criteria used to select one similar building over another. Energy-efficient systems and products must compete with many design attributes including overall design function, structure, comfort, aesthetic and high-tech appeal, and affordability. Determining where user demands for energy-efficient systems and products fit into the overall design process would help designers of energy-efficiency programs determine how to best promote the benefits of energy efficiency to users, owners, and designers.

The dynamics and structure of design teams for commercial buildings vary. A typical scenario involves an owner who, with a building development in mind, contacts an architect; the architect then hires an engineering firm. The owner deals almost exclusively with the architect and has little reason to interact with the engineer. Since the architect is the primary contact with the owner, meetings with the owner, architect, and engineer are unlikely unless they are arranged as part of a utility conservation program. Conservation programs that bring the owner, architect, and engineer into the same meeting may be taking some risks since this is probably a new and uncertain situation for all and there may be sensitivities. Architects may see little benefit to participating since the engineer is the expert in energy efficiency. Although there are few rewards for the architect's participation, a positive meeting may influence repeat business since the architect is the entity that the owner hires (Dethman, Bowles, and Elder 1991).

The two primary constraining aspects of new construction projects are time and money. The evaluation of energy-efficient products and systems impacts both of these in negative ways. Design professionals typically operate on fixed budgets, therefore any added time and effort required to consider alternative energy-efficient systems for a building is at their expense. Besides budget, keeping the project on schedule is another primary concern of designers.

Although early intervention in the design process would allow engineers more flexibility in terms of energy-efficiency options, engineers typically enter the design process at a later point than architects. Architects, for example, typically make choices regarding windows which are made early in the design process, while engineers typically become involved in the process later when HVAC systems are selected (Dethman, Bowles, and Elder 1991).

What type of influence do each of the design team members have on the design of energy-efficient buildings?

Commercial building design is a process that involves countless decisions regarding every aspect of the building. Different design team members influence this process to different degrees, depending on their designated role in the design process (i.e., owner, architect, engineer), their knowledge of the design component in question, and their ability to influence final design and product decisions. In their design capacity, architects tend to be most interested in the general aesthetics of a commercial building and are often less informed about energy-efficiency measures than are engineers (Spinney et al. 1991). Although they typically have the owner's ear, architects may have limited knowledge of energy-efficiency measures (Dethman, Bowles, and Elder 1991).

Generalizations can be made about each design team member's influence over the design process, for example owners typically have the final say regarding design decisions and consultants have a strong influence on certain building components.

How often do architects present clients with energy-efficient building component options that can reduce operating costs?

However, decisions regarding specific energy-efficient building components likely depend to some extent on the type of component in question.

According to a survey of architects conducted by Hattrup (1990), the decision to use daylighting in new buildings was influenced most by architects. The second most influential design team member was the client, and the third most influential was the lighting designer. This study also found that familiarity with daylighting practices influences the decision to use daylighting, which lends support to the notion that architects need to become better educated on the use of energy-efficient design practices and products if they are to encourage their use.

According to architects who responded to the 1993 PNL architecture survey, energy-efficient building options that reduce operating costs are presented to the client, on average, 69% of the time. Twenty-eight percent of architects say they present clients with this information all or nearly all the time (90% to 100% of the time), 34% say they present this information most of the time (70% to 80% of the time), 26% say they present this information about half the time (40% to 60% of the time). Twelve percent of architects rarely present this information to clients (30% of the time or less). Although it appears that architects typically present information on reducing operating expenses through the use of energy-efficient building upgrades to clients, there is still room for improvement. Figure 9 summarizes these findings.

Training on the savings that clients could realize from these energy-efficient building options, and the competitive benefits to be gained by architects who present these options to clients, may encourage architects to offer these design options more often.

Figure 9. How Often Architects Present Clients with Options for Reducing Operating Costs with Energy-Efficient Building Upgrades

What is the potential for energy savings at each phase of the building development process?

The greatest potential for energy savings occurs during the building design stages; therefore, it is crucial that energy-efficient design takes place early in the design process.

Because time and money are at a premium at the design stage, both the design team and the client must be convinced that the increased product costs and design efforts are worthwhile in terms of building energy efficiency and marketability of the final product. In addition, the design team is most open to new ideas and techniques at the early stages of building design (Keneipp et al. 1990). Figure 10 presents the potential for energy savings at each stage in the design process.

Figure 10. Potential Energy Savings at Different Stages of the Building Design Process (Keneipp et al. 1990)

How concerned about energy code compliance are different groups involved in the building design process?

Concern about meeting minimum energy codes by those involved in the process, and the public in general, can translate into higher energy code compliance. Based on the perceptions of architects who participated in the PNL survey, architects and code officials have a relatively high level of concern about energy codes, the general public is moderately concerned, and contractors and developers are only slightly concerned about energy codes. Architects were asked to rate concern levels on a scale from 1 to 10 (1 = very little concern, 10 = very high concern), and their perceptions are shown in Figure 11.

Based on these findings, it appears that more awareness about the energy-saving and environmental benefits of energy code compliance may be needed by all of these groups. The fact that developers and contractors appear to be even less concerned than the general public about energy code compliance is an important observation, and may mean that developers and contractors are misinformed about the importance of energy codes in the industry.

Figure 11. Concern About Energy Code Compliance by Different Groups According to Architects' Perceptions (1993 PNL Survey)

What are some of the barriers to energy-efficient design faced by building designers?

Lack of Information

A 1988 study examined a broad range of energy conservation programs for new residential and commercial buildings to determine how each program addressed barriers to widespread adoption of energy-efficient design and the use of better end use technologies in new construction (Vine and Harris 1988). The study considered four types of barriers: information, initial cost, technological, and perceived risk. These barriers are discussed below.

Information on energy-efficient design and product availability needs to be available to architects, engineers, developers, builders, and lending institutions. Energy design tools that allow energy-efficient technologies to be evaluated as they relate to a specific building are especially needed. Even highly motivated designers and architects may be hesitant to invest in cost-effective measures because of a lack of good information.

Initial Cost

In general, those involved in the design, construction, and operation of commercial buildings are very sensitive to initial costs. Long-term operating expenses of the building are of lesser importance, particularly for non-owner occupied buildings. Delays in the design and construction of commercial buildings result in increased costs, therefore programs to promote energy-efficient building design and construction need to minimize delays.

Inexperience with New Technology

Availability and service support for new energy-efficient technologies is often limited. Without a sufficient level of product availability and support, as well as documentation on performance, reliability, quality, and safety from a reputable institution, designers are typically unwilling to incorporate new technologies into their designs.

Perceived Risks

Some involved in the design and construction of new buildings may see the development of energy-efficient buildings as too risky, compared with the prospect of current-practice buildings. These people may prefer to wait until products are demonstrated beyond a doubt or until they are more familiar with the technology.

What types of lessons have utility companies learned during development and implementation of design assistance programs?

Utility companies have developed a number of design assistance programs targeted at building owners and designers to promote the design of energy-efficient buildings. These programs typically involve cash payments to offset the added cost of energy-saving measures, or other incentives to promote the use of energy-efficient products and help offset the added design costs.

The utility programs typically target building owners and developers, and architectural firms. Design assistance offered by utilities often involves design assistance to the main players involved in making building design decisions: building owners, developers, architects, engineers, and contractors. As part of their program review process, utilities often fund program evaluations that determine if the program is meeting its defined goals. Some program evaluations have investigated the factors that motivate different design team members to participate in design assistance programs.

A group of professionals who had worked with large-scale, utility, new commercial-building construction programs (Dethman, Bowles, and Elder 1991) reported their experiences in the paper "Consider the Culture: Lessons Learned from New Commercial Programs." Some attributes of successful programs that they uncovered are discussed below.

Program Flexibility

Programs must be able to adapt to various project needs such as energy savings potential, size, complexity, time constraints, and design team characteristics (design team or owner-dominated decision making). From a utility standpoint, the program flexibility needs of the design community must be weighed against the difficulties associated with managing a program with less clear guidelines.

Design Recognition

At least some design professionals are motivated by the opportunity to be recognized in their field for excellence in energy-efficient design, and some utility demand-side management programs offer this recognition with success. Utilities have found, however, that design competitions that result in "winners" and "losers" have been less successful due to dissatisfaction by losers.

Design Component Flexibility

Some utility programs offer a menu of energy-efficient design options while others promote programs that involve more comprehensive design assistance. There are pros and cons of each, and the best approach may be to offer both simple prescriptive and comprehensive performance-based design paths, depending on the needs of the design team and project.

Prescriptive approaches operate with the belief that many facilities would not participate if involvement is too detailed, time consuming, complex, and expensive, and that design team members are not that concerned with energy-efficient design complexities. They also believe that the menu approach is applicable to most projects, and therefore is most cost effective.

Proponents of comprehensive performance-based design programs argue that programs where brainstorming and modeling strategies are employed are best, especially since they may lead to long-term movement toward energy-efficient design in the marketplace by more actively involving designers in the process. They believe that energy savings in commercial buildings must be integrated into

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the design process and that true innovation occurs only within the process of design. They also believe the menu approach is more applicable to residential versus commercial buildings.

According to staff at Wisconsin Electric Power Company (Keneipp et al. 1990), a comprehensive approach to energy-efficient design should be encouraged in order to gain the most energy efficiency at the least cost. This approach allows the building design to be evaluated as a "comprehensive" whole, allowing for identification of the most efficient mix of energy-efficient options for the entire building. Prescriptive approaches, they argue, rely on design team members with specialized and limited focus to recommend systems and products without the benefit of evaluating the entire integrated building system.

**Tactful Information
Dissemination**

Architects and designers, like other professionals, pride themselves on their personal knowledge of their field. In some cases this knowledge may be incomplete or even incorrect. Utility program staff need to be sensitive to this when providing information.

Acceptable Incentives

Some utility programs have resulted in savings from design assistance without providing incentives, but most would have experienced greater participation that was cost-effective if incentives had been offered.

Delivery of Special Equipment

Construction schedules for commercial buildings are traditionally very tight, and a missed delivery of equipment can slow construction or result in the installation of a more readily available piece of equipment in order to keep construction on schedule. Designers are sensitive to the availability of products and consider availability when making design option decisions.

Design Community Involvement

The design community tends to be a fairly tight-knit culture. Program marketing staff that become involved in professional societies such as the AIA and ASHRAE, and local organizations such as the Chamber of Commerce, tend to be more successful due to the network of contacts resulting from their involvement.

**Where can I get more
information on building
energy codes and
developing successful
implementation programs
to promote them?**

This paper is made available by DOE and PNL and is intended to assist states and others charged with implementing building performance standards to achieve the maximum practicable energy efficiency in the design of new buildings.

DOE and PNL are currently supporting programs that involve practicing architects and engineers, professional societies and code organizations, utility companies, industry representatives, and researchers from the private sector and national laboratories. These programs have resulted in the identification and development of a variety of energy-efficiency design tools that are available from DOE at no cost.

**For more information,
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