Focus Group Discussions of Daylighting Practices

**B. F. Roberson
S. A. Harkreader**

November 1988

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SUMMARY

Focus group discussions among architects and engineers with experience using daylighting in building designs were held in two cities. The primary purpose of the discussions was to gain insight into barriers to more widespread use of new daylighting technology. Key findings and new hypotheses are as follows:

- Though clients are open to influence by designer suggestions, they often have established financial or design criteria. Most clients require a three- to five-year payback on added expenses.
- Developers who are owner/occupants are concerned with both initial costs and operating costs, while investment-oriented speculative developers focus on low initial costs.
- Developers will invest in daylighting features if they believe these features will increase the attractiveness of the building to tenants.
- It may be useful to assess and compare the occupancy and rental fees obtained for daylit and non-daylit buildings.
- Opinion was divided between those who did and did not believe that daylighting features could be justified in terms of the money saved through reduced energy consumption.
- The participating architects and engineers used daylighting primarily for its attractiveness and appeal for building users. Savings in energy costs were viewed as secondary.
- Daylighting was thought to be most appropriate for warehouses, hospitals, libraries, museums, and low-rise office buildings.
- Daylighting in high-rise buildings was viewed as typically requiring complex control systems that create excessive construction and maintenance costs.
- There was a consensus that daylighting can be best employed to provide ambient light and is inappropriate for task lighting.
- Many building designs call for expensive backup lighting systems to compensate for the unreliability of natural light.
- Most respondents in Los Angeles said that California Title 24 had the effect of restricting use of daylighting features in their designs.

- Excess illumination and resulting glare is a major problem with daylighting systems, especially in spaces where computers are used.
- Respondents said that daylighting would be used more frequently if practitioners had believable guidelines about when daylighting systems are most effective.
- Respondents had no experience with, and virtually no awareness of, computer simulation models that evaluate daylighting alternatives.
- Respondents did not think computer models could provide valid information on system performance and expressed greater interest in less expensive ways to develop physical models.
- Respondents said an effective way to increase daylighting would be to create greater demand among their clients and the general public.
- Daylighting could also be increased by training designers in new methods, products, and benefits.
- Information about daylighting innovations reaches architects and engineers through journals, seminars, and sales people.

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INTRODUCTION

This research was sponsored by the U.S. Department of Energy (DOE) Office of Buildings and Community Systems and conducted by Pacific Northwest Laboratory (PNL) as part of an ongoing effort to enhance the commercial use of federally developed technologies. One such technology is the use of daylighting practices in the design of nonresidential buildings. This document is a report of the findings from meetings of focus groups conducted to gain insight into building designers' perceptions and attitudes about daylighting systems.

The use of natural light to illuminate building interiors has a long history. However, less emphasis has been placed on this technique since the introduction of safe and relatively inexpensive electric light. The increase in fuel prices initiated by the 1973 oil embargo made daylighting practices a design option once again worth serious consideration. Investments in daylighting systems offered opportunities for significant energy and dollar savings (Selkowitz and Griffith 1986).

As of 1988, interest in daylighting practices has again shown a declining trend. The current stability in the price of oil is almost certainly a contributing factor. Though the immediate need for use of renewable energy has declined, some organizations have discovered that the use of daylighting offers some long-term benefits. For example, Yellott (1987) observed that daylighting can help reduce the energy required for lighting and cooling during mid-day peak periods. Reducing electricity demand during peak periods offers substantial dollar savings for utility companies. Consequently, some utility companies have continued to examine how daylighting can help them control production costs.

Though many utility companies no longer have active daylighting research programs, others have continued to promote daylighting practices. For example, Southern California Edison (1986) published a booklet titled Daylighting: Performance & Design, which provides an introduction to daylighting issues, an overview of daylighting options, and several case studies.

Despite the efforts of the various companies and individuals interested in promoting more widespread use of daylighting practices, there is no evidence that design professionals are making use of the available knowledge and technologies. Given the apparent financial benefits of applying daylighting technologies, one may question why they are not more readily adopted. The nature of the barriers to the use of daylighting practices must be understood if programs designed to promote their use are to be successful. Market research is the appropriate method for gaining such understanding.

It is possible that the information being disseminated is not being presented in a persuasive manner or is not reaching the right people. Market research, such as the use of focus groups reported in this document, can provide insight and guidance on these issues. Market research methods address both problems and solutions from the perspective of technology users rather than technology developers. It is intended that this information will be used to develop marketing programs that will lead to more frequent use of daylighting practices by architects and engineers.

This information will also be used to guide decisions on appropriate directions for future product research, to make a more useful product, and to show utility and manufacturing companies the profit opportunity they can have by investing in the development of daylighting technology.

COMMENTS ON QUALITATIVE RESEARCH

Qualitative research methods, such as the use of focus groups, are not intended as substitutes for quantitative methods. Since focus groups consist of a small number of selected respondents, results cannot be quantified and projected to a larger universe. Rather, the groups are intended to provide insight into consumer perceptions of, and reactions to, the products and ideas of interest. Though it is intended that all meaningful perspectives will be represented in the groups, it is inappropriate to use focus groups as a source for drawing conclusions regarding the magnitude of importance that the various concerns have among the larger population (Advertising Research Foundation 1985; Greenbaum 1988).

The strength of the focus group method is in generating insight into individual perceptions and reasoning. Consequently, the analysis should facilitate understanding of the respondents and their reactions. Survey research that follows can clearly be improved through the learning obtained in focus groups. Understanding of consumer language, perceptions, and the range of responses to critical issues all contribute to superior quantitative research. The insight gained from qualitative research helps both in the development of testable hypotheses and in interpreting the data.

KEY ISSUES

Participants were asked to address several areas of specific interest. The major topics for discussion were as follows:

- positive and negative attributes of daylighting designs
- changes and trends in the development of daylighting technology
- sources of information about daylighting, including computer simulation software
- differences in the decision processes used by building designers and their clients
- increasing the demand for use of daylighting in nonresidential building designs.

METHOD

The focus group method consists of conducting loosely structured discussions among small groups of individuals. Individuals are selected to participate in these discussions in a way designed to ensure that all relevant perspectives are represented. This section contains a detailed description of the selection process and research procedures employed in this study.

SAMPLING PROCEDURE

The names of potential participants in the focus groups were obtained from membership lists of appropriate professional associations and by personal references from such members. The respondents were contacted and screened through a telephone interview. Respondents were informed that they would receive a \$100 cooperation fee when they completed the interview. Those agreeing to attend were sent a follow-up letter as a reminder.

Respondents were selected from a list of qualified candidates in the metropolitan areas of Los Angeles, California, and Chicago, Illinois. Respondents were screened to ensure an acceptable level of professional experience in general and some experience working on daylighting projects. Specifically, all respondents identified themselves as either architects or engineers who were involved in commercial building design and had at least two years of professional experience. Respondents also stated that they had participated in the design of a nonresidential lighting system during the previous year and that they had used daylighting practices in such a design during the previous two years.

Two group discussions were held in each of the test cities. The groups consisted of between seven and nine individuals. A total of 31 architects and engineers were included in the focus groups.

PROCEDURE

Seven to nine individuals participated in each group discussion. The discussions took place in standard focus-group facilities. The conference

rooms used had visible microphones at the table and a one-way mirror along one wall. Respondents were informed that their discussion would be tape recorded and observed by viewers behind the mirror. The discussions lasted from one and a half to two hours.

Focus group sessions entailed a semi-structured discussion format led by a moderator. The moderator introduced topics for discussion, asked questions to probe key comments, and made sure the discussion remained relevant to the topics. Respondents were free to comment on the topics.

RESULTS

At the start of each discussion, daylighting practice was defined for the respondents as "the planned use of natural light as a substitute for artificial light." The respondents found this definition to be reasonable. However, they felt that it was important to recognize two things. First, that although natural light can be used as a partial substitute, or supplement, for artificial lighting systems, it is not reasonable to propose natural light as the only lighting system for a building. Second, that the presence of windows does not necessarily mean that natural light is being used to supplement the artificial lighting system at all. For example, windows that are coated or glazed do not necessarily support a daylighting system. A daylighting system must both introduce natural light into a space and also use that light to reduce the amount of energy used to generate artificial light.

The decision whether or not to use a daylighting system in a building is a complicated one that can involve many people, a variety of incentive structures, and a number of situational constraints. In addition to perceptions regarding the benefits of using daylighting practices, respondents' perceptions about this decision-making process will be discussed.

The benefits of using daylighting in building design identified by the respondents can generally be categorized as either qualitative or quantitative. The qualitative attributes are those that can be expected to affect the feelings of people who view or inhabit a building. These are not easily measured. Quantitative attributes are generally expressed in terms of costs. Cost issues can be categorized as those pertaining to initial costs and operating costs. This distinction is important, since building users may not be directly affected by both types of costs.

Energy efficiency and conservation were regarded as components of operating cost and seemed to have little merit independent of cost issues to the participants. Therefore, little time was spent discussing the value of using renewable energy for reasons other than cost.

DECISION MAKING

The decision to include or exclude daylighting from a building lighting system is influenced by a number of people and situations. The people identified as most influential with respect to this decision were 1) the clients employing the architects and engineers and 2) the architects and engineers themselves. The critical situational variables that affected the decision were 1) the primary function of the building and 2) relevant building codes. Those four factors are discussed in the following subsections.

Financial and budgetary issues also affect decision making, and cost is an important product attribute. Cost issues will be presented in a separate section of this report.

Clients

The participants felt that ultimately, and appropriately, their clients were the ones who decided whether or not a building would have a daylighting system. There is no question that design professionals are in a customer-service business. The clients pay for a building, and if architectural and engineering firms want to stay in business, they must produce the kind of designs that their clients want. The participants in the focus groups said they were quite responsive to clients' perspectives but that they also contributed their own expertise to the design of their buildings. In their words:

- "Although we do make a lot of the [decisions], when the client says, 'jump' we jump. You want the job."
- "It depends on what the clients are looking for."
- "[Clients] generally don't care about saving energy, they just care about aesthetics and exposure....But as an architect, we take into consideration that you can save energy also."
- "If [daylighting] is not brought to the table by a client, a lot of times it's not discussed."

Some corporate clients allow design consultants very little flexibility. They may have staff architects and engineers who design the basic framework and systems for a new building and employ consultants only to supervise completion of detail work. Other corporate clients, especially retail

outlets, may have a look or theme common to all their buildings. Architects simply adapt these designs to local conditions. They are not given the option of introducing novel systems, such as daylighting.

However, many clients allow more flexibility, depending on the consultants to make the important design decisions. The participants reported that they sometimes make critical decisions because an appropriate decision maker cannot be identified in the client organization.

- "It might take the CIA to figure out who [the decision maker] is. We have a hard time figuring it out sometimes, and we have them all in one room!"
- "Trying to identify who the decision makers are in a corporate structure is difficult."

In these situations, the consultants may be free to decide in favor of using daylighting practices.

On the other hand, clients sometimes request daylighting features for specific reasons. One reason that was frequently mentioned was to take advantage of financial discounts and rebates offered by utility companies.

- "Clients are sophisticated and know what rebates and breaks utilities offer."
- "Utility rebates definitely influence our clients."
- "[Utility promotions] really are an incentive."

Others may request the inclusion of daylighting options for aesthetic reasons or to reduce operating costs.

- "Most corporate clients are conscious of making a pleasant environment."
- "Commercial clients are generally looking for the effect on the environment, the more pleasing environment of natural light. The industrial [clients] are looking for efficiencies. The return on their dollars."

While some clients intend to occupy the building when it is completed, others intend to lease the space out. The latter group views the building as an investment from which a reasonable rate of return is expected. Effort is made to minimize the initial cost of the buildings while achieving a high

level of "leasability." Since the occupants may not be known or may change, buildings must be adaptable and maximally functional, as well as attractive. Daylighting is viewed as important only for effect.

Developers are not much concerned with the effect of daylighting on operating costs for four primary reasons. First, developers do not pay the operating cost themselves, so they do not directly benefit from reduced energy costs. Second, developers do not believe that this variable contributes much to a potential tenant's decision to rent a space. Tenants are thought to be more concerned with location, view, and space. So developers do not see even an indirect benefit to themselves from energy cost savings. Third, daylighting features often increase building costs. When budget cuts are to be made, daylighting features are often the first to go. Finally, developers are reluctant to risk their money building a unique structure. It is viewed as a safer investment to select a design that has been used locally and has attracted many tenants. If there is a popular daylight building in the area already, other developers may be more open to including daylighting features in their buildings.

Architects and Engineers

The architects among the focus group participants viewed themselves as the general managers of building design projects. Though they receive information from many sources and their decisions are influenced by a number of other people, most felt that they were usually responsible for the decision regarding the type of lighting system in a building. In the words of the respondents:

- "[Architects] are the ones who decide if a building is going to have natural light or not. That's for sure."
- "If you are a good architect you can guide your client in what is needed in a building."

Though architects often turn to consulting engineers for specific system design information, they viewed the engineers as technical support for the implementation of a decision they had already made. The architects are the ones who decide which consulting engineering firm to hire. They typically hire engineers known to specialize in the type of system they have already

decided to use. In other words, the expertise of the engineer is important, but it generally becomes relevant only after the basic design decisions have already been made.

From their central position, architects identify and integrate the design parameters for a building. Client needs and budget constraints must be integrated with system performance information, environmental and administrative constraints, and the architect's own skills and preferences for design of an attractive and functional building. Although the client can veto any idea, it is often up to the architects to submit a design that they feel will best serve the needs of the clients.

Function Of The Building

Buildings designed for different functions vary in their appropriateness as candidates for use of daylighting features. The architects and engineers generally agreed that daylighting was most appropriate for low-rise buildings (generally, those having fewer than five floors). It was felt that the cost of lighting controls necessary to use daylighting in high-rise buildings was simply too high.

- "I think any low-rise structure, like a warehouse or a three- to four-story office building...it can be successful there. It's mostly passive. When you get into the high-rise, you get into controls, and the cost becomes prohibitive."
- "Most of the structures we use it on are low rise or single story."
- "Warehouse-type buildings are a good source for [using] natural light."

Other respondents placed more emphasis on using daylighting in situations that maximize the qualitative superiority of natural light over artificial light. As one respondent said:

- "Small buildings that have a real definable function--libraries, museums, things like that: I think daylighting could save money for them."

Successful daylighting systems are often designed to use natural light for specific, limited purposes where it is most effective and artificial light where greater reliability or intensity is required. For example, many respondents said that daylighting was most effective when used in common

areas of low-rise buildings, where fluctuations in illumination level do not generally create problems. The designer can use natural light to provide ambient or general-space lighting in such areas without leaving building occupants dependent in other areas on natural light for specific types of work that may require high and dependable illumination.

- "[Daylighting may be used in] common areas of schools, etc., but for classrooms not particularly, because you can't count on the quality of light for every station."

Building Codes

Respondents in the Chicago market felt that building codes had very little effect on their decisions regarding lighting systems. In fact, when asked about local codes, most respondents seemed disinterested and not very knowledgeable. They seemed to view building codes as a set of common-sense, minimum requirements for safe designs; they assumed that if they did good work, their designs would meet the standards of the building codes. Given these attitudes, it is not surprising that these respondents felt that building codes had very little effect on their decisions about when to use or not use daylighting.

Respondents in Los Angeles responded very differently to questions about the role of building codes in their work. Many felt that their work was dominated by regulations imposed through California Title 24. This legislation is the framework for many local building codes and sets specific requirements for the minimum projected energy use allowable for new commercial buildings. Most respondents in Los Angeles felt that Title 24 generally reduced opportunities to use daylighting in building designs.

The respondents said that Title 24 had the effect of restricting the square footage of glass that could be designed into the envelope of a building, because even when glass has an insulating glaze or layer, heat loss is expected to be higher than for drywall. Further, the contribution of daylighting to energy savings through reduced electricity needs for lighting and cooling is minimized in the Title 24 calculation. The net result is higher-than-normal projected heat loss for daylit buildings that is not offset by anticipated savings in energy for lighting and cooling. In other

words, the formula for calculating energy use maximizes the negative effects of daylighting systems and minimizes the positive effects.

The respondents said that eliminating daylighting apertures from their designs is often the most expedient way for them to comply with Title 24 requirements. Most of the architects in Los Angeles said they would use daylighting in their designs more often if they were not restricted by Title 24.

In addition, respondents observed that daylight cannot be included in assessing compliance with lighting illumination requirements for many public buildings. For example, public schools are used mostly during daylight hours, so it may be reasonable to use daylighting for common areas in schools. However, building inspectors can and do check compliance with minimum illumination requirements at night. Knowing this, architects must design a system that meets these requirements day or night. Given these limits, it is difficult to identify cost-effective uses for daylighting systems that also meet requirements.

QUALITATIVE BENEFITS

How light is used in a building is considered to be a basic design decision. Control of the use of light in a building is one of the tools architects use in developing functional and attractive buildings. Architects and engineers clearly felt that the freedom to use natural light in their designs was an important option.

- "One thing an architect can use to shape and sculpture a building is control of the light."
- "We walk a tightrope....One time you have to be an engineer, and the next you have to be an artist."

The use of natural systems for light and ventilation is not a high priority at schools of architecture, nor among most clients. In fact, daylighting seemed to be viewed as a lost art that most respondents held in high esteem. The respondents often spoke nostalgically of the time when architects routinely used natural light in their designs. One respondent spoke of a colleague and his approach to building design:

- "I work with an older architect who, whenever he designs something, he draws a sun diagram first...and a wind chart....Then he orients the building to the sun. This is the intelligent way to go about it."

Architects and lighting engineers seem to value daylighting most highly for its qualitative benefits. Daylighting is perceived as a means of enhancing building attractiveness for users. Respondents generally accepted without question the notion that most people are happier and work more effectively in natural light than they do in all artificial light. In addition, they felt it important that users of a building be able to "connect" with the outside environment. Having an unobstructed view of the outside was beneficial to building occupants. Comments on this topic included the following:

- "Using daylighting in an office building [is] more for psychological effect, because [one] has contact with the outside."
- "Natural light is always a better working light."
- "Natural light is better for eyes."
- "It's more pleasant."
- "If corporate clients care about their employees, they put in systems with [natural light]."

A good view and large windows are also a strong selling point for most types of buildings. Corner offices typically command a premium price because they have more window space. The architects consistently reported that their clients know this and ask for designs that maximize "leasability" by ensuring sufficient window space for all offices. Natural light is perceived as adding real value to buildings. In the words of the respondents:

- "The more glass you have, the [higher] rent you can collect."
- "Sometimes a building [with skylights] can have so much charm that it will rent where a building that didn't have such charm will not rent. [Such a building may] pay for itself in a very short period."
- "The developer will pay more if this building is going to get tenants."

Respondents were not aware of any evidence that daylight buildings generate higher-paying and more reliable tenants than non-daylit buildings, but this perception is firmly held. As a rule, the respondents perceived daylight buildings to be more attractive, and it just made sense that tenants would pay for this benefit.

A study providing evidence of higher and more consistent rental returns would most likely provide useful information for architects and lighting engineers. It could not only reinforce their perceptions of the value of daylighting features but also help convince developers of the long-term value of daylighting.

Windows that provide views to the outside may not necessarily be part of a daylighting system. For example, reflective low-E coatings on glass often block light from entering a building. During the course of the discussions, some of the participants did not seem to distinguish between windows that provide views and windows that admit natural light into a building. They spoke of daylighting when their concern was for a window with a view.

However, some of the participants stated that a daylighting system must introduce sunlight into a space in an unadulterated form. Tinted glass was inappropriate because it interfered with the building users' "connection" with the outside. Natural light was thought to facilitate a sense of the passage of time during the day and an awareness of the outside environment through the seasons. This connection with the larger environment was thought to be a primary contributor to the psychological benefit of natural light for building users.

It is important to remember that the working definition of daylighting specifies that natural light be used as a substitute for artificially generated light. However, designers do not always take advantage of the opportunity to save energy through the use of daylighting features. As one architect stated:

- "[It is not unusual] to see glass walls and the lights on right up against the wall...That doesn't save energy."

The qualitative benefit of enhanced attractiveness of a building, which is thought to contribute to leasability, may sometimes be offset by the

reduced square footage of leasable space that can result from the inclusion of atriums, sunrooms, or other daylight common areas.

COST ISSUES

The two major cost issues raised in the discussions were initial purchase and installation costs for daylighting features and the effects of these features on the long-term operating costs of a building. This distinction is important because the owner may or may not be directly affected by both of these costs.

The architects and engineers categorized their clients as either owner/occupants or developers. Clients described as owner/occupants included large corporations and public organizations such as hospitals, school districts, and government offices. These organizations typically commission the design and construction of a building for their own use. Naturally, the owner/occupants were perceived as being highly concerned with the anticipated costs of operating a structure. Developers, on the other hand, typically intend to rent the structures to other organizations and to occupy little, if any, of the space themselves. Developers are perceived to be interested in the operating costs of their buildings only insofar as this factor affects rent levels and occupancy rates.

Initial Costs

Installation of daylighting features invariably increases building costs. It was observed that any opening in a building requires additional labor, time, and materials compared to drywall. In addition, all openings in a building add to security problems. Windows and skylights must be resistant to vandalism and break-ins. This can often add to the initial cost of these features given the need for reinforced glass, ironwork over skylights, or other security measures.

Since daylighting generally adds complexity to a building's design, the cost of planning and coordinating various systems may also increase. The architects and engineers in the focus groups believed that daylighting consistently added to total cost.

- "The initial cost of daylighting is usually higher."
- "It does take extra engineering effort to do daylighting...which means more money."
- "The control systems used along with daylighting...are very costly and somewhat complex."

A few of the architects said they were able to reduce some material costs by reducing the number of permanent light fixtures in daylit buildings, although they planned for "task lights" at individual work stations. The number of lighting fixtures was often reduced at the client's request.

- "[For one client] the first building we did had lights right up against the glass...For the next building he said, 'I want to take those out; I never use them.'"
- "We've had repeat clients...and they've asked us to make some changes in the amount of artificial light: to reduce it, because they know they are getting [a lot] of light through their windows."
- "I've actually reduced the number of two-by-four [light fixtures] as I go toward the window wall if the building is going to be used mostly in the day."

However, several of the architects and virtually all the engineers we spoke to felt that it was inappropriate to reduce the number of overhead light fixtures. This decision seems to generate frequent disagreements.

- "The architects want the daylight and the engineers say, '...it gets dark and you've got to put the lights in anyway; you can't afford both [light fixtures and daylighting features].'"
- "I'm going to put those lights in anyway, because it gets dark sometimes."
- "You can't rely on daylight in a school, because what if they have a dark day? What if they want to meet there at night?"
- "You've got to have supplemental lighting for any structure."

In summary, respondents believe that it almost always costs more to install daylighting features than not to install them. Even if savings can be made by reducing the number of light fixtures, costs are likely to rise due to higher planning and installation costs. Given that this supposition is correct, the question becomes one of whether the higher installation costs

can be justified. In other words, is the added cost of daylighting recouped in a reasonable time period through reduced energy and operating costs?

Operating Costs

The two major components of operating costs are energy consumption and equipment maintenance. When deciding if daylighting features are worth the added cost, the determining factor is an expected reduction in operating costs through reduced energy consumption. The required size of the expected cost reduction is quite clear in most cases. The architects said that most of their clients expect a two- to three-year payback for added features, although some of their institutional clients, such as school districts, may accept a payback period of beyond five years. If saving in energy costs is the primary justification for installing a daylighting system, clients must be convinced that a three-year payback is reasonable.

Several of the respondents felt that daylighting can be economically viable if all the economic consequences of installing such a system are considered. As stated earlier, daylighting may allow fewer overhead light fixtures, helping to offset installation costs of skylights. Daylighting may also help reduce heating costs in the winter and air-conditioning costs in the summer. It was felt that daylighting could indeed pay for itself if these savings were added to the expected reduction in energy costs for lighting.

Energy Consumption

Many respondents felt that there were design conditions in which daylighting would be the best financial decision. While some architects seemed quite certain of the energy savings potential, others were not confident that they could prove it.

- "There are significant savings in your light levels...which is one of your bigger energy users--[more than] for heating and cooling."
- "We use daylighting primarily for reduction of fixtures, and therefore, energy."
- "I would say that you could save energy by using daylighting, but it's not a guarantee."

However, several other architects said they did not believe that daylighting features could ever be justified in terms of the money saved through reduced energy consumption. Even those who advocated the use of daylighting to obtain qualitative benefits often felt the energy savings would be trivial.

- "I don't think you are going to sell [daylighting] on the basis of energy savings."
- "You could waste your [energy savings] on HVAC if you have the windows in the wrong spot."
- "Daylighting contributes a tremendous amount of heat gain to a space and [you are] going to spend more cooling it than you gain from lighting. That's our experience with it."

Other architects stated their belief that if a daylit building did not save energy, it was the architect's fault. Either the building was not correctly oriented to the sun and the local environment or the components of the building were not correctly integrated. Several architects expressed concern about using daylighting in buildings because there was no way to be sure that the system would work.

Perhaps the greatest problem in justifying the economic value of daylighting is the lack of precise, credible information. An architect may tell a client that daylighting an office lobby should reduce energy consumed for lighting the space by 30% and air-conditioning needs by 10%; however, most architects do not have much confidence in such predictions. There seem to be too many unknowns; too many things can go wrong. Besides, there is no easy way for most builders to test such a proposition. How can they really know if they are saving money on energy costs?

None of the architects in the focus groups said they had tried to convince their clients to use daylighting features to reduce energy costs. Rather, the primary advantage that they present to clients is the aesthetic effect. Energy savings are usually presented as a likely secondary benefit. However, clients sometimes ask for daylighting features because they already believe that such features lower operating costs. In these circumstances, the respondents said they happily support this assumption because they believe that it is generally correct.

Maintenance Costs

A sometimes hidden cost of daylighting systems is that associated with maintenance. Even buildings with passive systems may have more glass and seams to be maintained, repaired, and cleaned than similar non-daylit buildings. Louvers, blinds, and other aperture covers that adjust illumination levels all add to the maintenance costs. Even the simplest daylighting system requires the maintenance crew to be more highly trained and may involve additional hardware costs. The problem is exacerbated in the larger, more complex systems, but respondents clearly expected higher maintenance costs under all circumstances.

- "There's more maintenance involved."
- "The advent of the [personal computer] made system control easier but created its own set of [maintenance] problems."
- "At [daylit] facilities you need a maintenance crew that can handle a large central plant."
- "The more sophisticated the systems, the more sophisticated the maintenance you need."

Not surprisingly, computerized, automatically adjusting systems are the most expensive systems of all. These systems respond to measures of illumination from sunlight and adjust the output from interior lights accordingly. Breakdowns in those systems may require bringing in both lighting engineers and computer programmers. One architect described how the problem was resolved by one of his company's clients:

- "We tried to use photocells to adjust the lights in the first 15 feet near the window. But because of complications, . . . the client said, 'Forget it.' So we put in an on/off switch."

One respondent described his view quite succinctly: "The simpler, the better." This view drew comments of agreement from virtually everyone else. They said their preference for simplicity applied to all building system, not just daylighting. In any case, it was clear that the more complicated the lighting control system, the less likely it was that they would employ it in their designs.

PERFORMANCE ISSUES

Though daylighting systems have many important benefits, they suffer from an inherent problem of unreliability compared to alternative systems. Daylight may provide all the illumination necessary most of the time. However, there is often an implicit or explicit requirement that adequate illumination be available in a building all the time. For example, daylighting may be perfect for a factory if its employees only work dayshift. However, such a system may be inadequate if there is any possibility of using the facility at night. Similarly, daylighting may provide good illumination to school rooms or offices 360 days a year, but it may be that the schools or businesses could not accept five days of poor lighting every year. That being the case, these organizations would insist on a back-up system. As stated earlier, it is often expensive to have both a conventional lighting system and a daylit system.

A related issue is preventing over illumination in a daylit space. This problem may reduce comfort and lead to reduced visibility because of glare on surfaces. Surface glare is an important problem, especially when users of a building are using computers. Too much light in a space and the resulting glare can make computer screens difficult to see. Given the trend toward using more computers in businesses, this problem is becoming increasingly important.

The added costs for the purchase and maintenance of mechanisms to control illumination levels has already been discussed. Simple manual controls, such as shades or blinds, can be ignored or unreliably used by occupants. Automated systems may not adapt well to the needs of individual users. In addition, designers seem not to have much confidence in the performance of complicated systems and have said that they are unlikely to use them.

INFORMATION ISSUES

This part of the discussion dealt with three general topics: first, the sources of information about daylighting available to the designers; second, the type of information they felt was the most useful to them; and

third, the respondents' familiarity with computer software to facilitate simulation and evaluation of daylighting designs.

Sources of Information

Respondents said they learn about innovations in their field primarily through academic training, professional journals, sales representatives, and seminars and conventions. Some of these sources are relied on more than others, and some are seen as more reliable and valid.

The architects and engineers in the focus groups generally felt that they learned very little about daylighting systems during their academic training. Though they recalled some exposure to the issue, none of the architects or engineers had had a class specifically on daylighting techniques.

One respondent said he did use a daylight simulator for physical models when he was in college. However, this was used to examine the aesthetic impact of light entering various spaces of the model, and its use was unrelated to energy concerns. In fact, the respondent was not sure if the simulator could provide a good basis for assessment of energy use in a proposed building.

All of the respondents had access to professional journals and felt that they were an influential source of information. Credibility of information about new technologies in the journals was high, because the authors were perceived as having no vested interest in giving a positive or negative evaluation of specific technologies and because reviewers and editorial staff of the journals ensure the validity of the articles. Some architects did feel that case studies in the journals were often unique or so specialized that they were not really relevant to the daily activities of most architects.

Architects and engineers also learn about new daylighting technologies at professional conferences and seminars. However, attendance at these meetings seems to be low among designers in smaller companies. It may be more difficult for smaller firms to absorb the cost of sending employees to these meetings. Employees at the smaller firms may also see less need to

develop special skills or awareness of the latest technological advances. Designers at small firms are especially prone to view themselves as generalists and to bring in technical consultants on an as-needed basis.

Sales representatives of the firms that produce building materials and heating and air-conditioning equipment are another source of information about new products and procedures. This information is not considered very reliable; sales representatives may give different information emphasizing their products, and these inconsistencies may create confusion. However, sales people are regarded as a common and important channel for information about new developments. Some sales people may promote the use of daylighting practices because they are in a support business.

Academic courses, journals, and seminars are all sources of information that rely on the designers themselves to take the initiative to learn. However, sales representatives of related businesses seek out architects who could employ daylighting technology and try to show them how and why to use it. Sales representatives probably have more influence on small design firms, where architects are less likely to be specialists and attendance at conferences is less common than in large firms.

Information Needs

When asked what kind of information they need to use daylighting practices more frequently, the respondents focused on making daylighting benefits easier to conceptualize and evaluate. As mentioned earlier, designers do not feel comfortable making claims to their clients about energy savings attainable by use of daylighting. By contrast, architects would have no reservations about discussing the energy savings attainable by adding insulation to the walls of a building.

Although articles about energy savings through the use of daylighting do appear in professional journals, conclusions are often limited to a narrow set of circumstances that characterize the case study being reported. Design professionals often have difficulty generalizing such findings to the kinds of designs on which they routinely work. If architects cannot say with certainty how much energy can be saved, they cannot justify the added initial cost to their clients. As a result, even when designers are sure that

daylighting would save energy in a particular design, they may not seriously consider adding daylighting features. The need to provide specific data is not an issue if daylighting is being employed to achieve qualitative benefits.

Participants in the focus groups expressed the need for guidelines regarding general performance of daylit spaces and most appropriate situations for the use of daylighting techniques. The level of illumination of a space by natural light is influenced by such factors as wall color and the arrangement of furniture. The sensitivity of daylit systems to so many unstable variables contributes to the designers' uncertainty about the energy performance of the systems. Some standard reference points for evaluating daylight systems would be likely to result in more frequent consideration of such systems by design professionals and greater acceptance of daylighting features by their clients.

The need for such reference points seems greater for designers in small companies than for those in large organizations. Those in smaller offices have fewer resources and greater pressure to keep costs down. They are more likely to adhere to designs that are not controversial. However, general guidelines on the performance of daylighting systems would be useful to all architects and engineers.

Any comparison standard for daylighting would have to be easy to understand, as well as statistically valid. For example, the base could be the national average of energy used to illuminate buildings of a certain type. Anticipated energy use in a daylit design could then be expressed in terms of an index to the national average. A rating system could then be devised; for example, a score below 100 might mean the design is expected to use less energy than average and a score above 100 might mean it would be expected to use more. Of course, an illumination index is just one possible approach. The important point here is that participants in the focus groups indicated that architects would probably use daylighting more frequently if there were concise, credible reference points from which to evaluate and communicate about the system.

Design Simulation Tools

Group participants were asked to describe their knowledge and use of computer programs to simulate the energy consumption of design variations in general and daylighting effects in particular. Respondents were asked specifically if they had used the DOE-2 software. Surprisingly, none had. In fact, although two respondents said they had heard of DOE-2, neither of them knew anything about it.

Respondents were asked about other computer software relating to daylighting and energy simulations. None of the participants had ever used such a computer simulation program and none could name an available program. Several respondents expressed the belief that three-dimensional computer models were probably too expensive and too complicated for them to use.

Several respondents said they did not trust projections made by energy-use models because such models were based on multiplicative formulas, so errors for any input become magnified in the final estimates. With such a large error, term projections may have a confidence interval of plus or minus more than 50%, which is so large that the projected energy use holds little practical meaning. Some respondents said they preferred basing forecasts of energy use and illumination on physical models, but again, this is time consuming and expensive; consequently, this practice is generally limited to special projects done by the larger design firms.

Information Recipients

Respondents were asked what group they thought would be the most appropriate to educate about the benefits of daylighting in order to increase its use in building designs. Although no consensus was reached, three potential target populations were suggested by the respondents: architects and engineers, their clients, and the general public. Respondents offered sound reasons for selecting each of the proposed target groups.

Some felt that daylighting use would increase most if more information were available to architects and design engineers, because they are the technical experts and are typically responsible for developing designs. If

they are convinced of the value of daylighting practices, they will employ them more often in their designs.

Other respondents thought it would be more useful to direct information to clients or building developers. They argued that designs developed by architects include features their clients want, and if clients ask about daylighting features, architects will be more likely to learn about and use them. Respondents felt that educating clients could help to reverse the tendency for daylighting features to be the first items removed from a design because of budgetary constraints.

Respondents who felt that it would be most appropriate to direct information about daylighting to the general public reasoned that clients are very responsive to trends and the desires of the general population. Corporate clients often want an atmosphere that is perceived as pleasant and modern by both clients and employees.

Regardless of the population suggested as the focus for educational efforts to increase the use of daylighting, there seems to be a common perspective: that is, a client-service orientation. Designers strive to please their clients; the clients, in turn, want features that will best serve the needs of their customers.

Throughout this decision-making chain it seems that assumptions are being made by the decision makers about what their clients want. Corporate developers have views about the effects of natural light on the attitudes and productivity of their employees. If they feel it is important, they may pay more to include daylighting features; if they are not convinced of its value, daylighting may be used only when it does not add to initial cost.

Speculative developers are concerned about the priorities of potential renters. If they believe renters are not concerned about operating costs, they are unlikely to spend additional dollars to keep lighting costs down through the use of daylighting practices. However, they may invest the money if they believe their customers prefer these features.

Three target groups were identified for information-oriented campaigns about daylighting. It may be useful to determine what information is most

influential in the decision process for each group. In promoting daylighting practices, it is important not only to identify those involved in the decision process but also what information will affect the final decision.

CONCLUSIONS

In this section key results are briefly summarized and some interpretation of these findings is presented. Some appropriate next steps are recommended. While these results increase understanding of the issues, the reader is reminded that focus-group results are neither quantifiable nor projectable to a larger universe.

Issues associated with the decision-making process are also closely associated with information needs. One of the most important information gaps is the question of who the primary decision makers are. The populations identified in the focus groups as the most important were architects and engineers, building developers, and building occupants. It would be useful to establish the relative importance of decisions made by these groups of people and to determine how they effect each other. Once target groups are identified, it is important to determine what information would have the greatest positive impact on their decisions about the use of daylighting. Precisely what type of information would lead them to decide on the inclusion of daylighting features in a building?

Both building designers and developers focus on serving immediate client needs. This often forces attention on immediate costs and short-term results. Virtually none of the participants in the focus groups considered life-cycle costs of daylighting features. It was felt that features that could not pay for themselves in three to five years could not be justified in terms of financial and energy savings. Thus, it would not be very persuasive to tell buildings developers about benefits of daylighting that accrue over the 25-year life of the equipment.

Saving energy, however, was often viewed as a secondary benefit, when it was considered at all. The main reason given for using daylighting was to obtain qualitative benefits. Daylighting features were seen as improving the attractiveness of and the quality of the atmosphere in buildings.

Daylighting is often used to improve aesthetics and obtain psychological benefits for the building users. Introducing natural light is the only way to obtain these effects. However, compared to artificial light, natural

light has some performance problems, primarily with respect to reliability. Changes in season, time of day, and local weather conditions can create fluctuations in the illumination of a given space. Many building users demand a high level of stability in the illumination. To obtain this stability in a daylit system, expensive back-up lighting and control devices are often required.

Some types of buildings were regarded as more appropriate candidates for saving energy through the use of daylighting than others. Many respondents felt that daylighting was best used as an ambient light source for warehouses, hospitals, schools, libraries, museums, and low-rise office buildings.

It was generally agreed that high-rise buildings required the addition of complex lighting controls to daylighting systems. Most respondents felt this expense was difficult to justify. They also said it was usually a mistake to use such a complex system. The complexity typically resulted in higher maintenance costs and more frequent breakdowns. They are also more expensive to integrate into the other systems in the building.

Respondents in the Chicago groups felt that building codes had little effect on their decisions regarding lighting systems. However, those in Los Angeles said that California Title 24 dominated and restricted their designs. This code sets requirements for energy efficiency in buildings but does not recognize the energy savings possible through daylighting.

The focus-group participants expressed the need for some guidelines regarding the general performance of daylit spaces and most appropriate situations for their use. Their primary sources of information about innovations in daylighting technology are professional journals, seminars and conferences, and sales people from producers of related products.

The participants also said quantitative information on the value of daylighting for building users and building developers would be helpful. Many decisions are based on assumptions about client perceptions, and it would be helpful to actually measure these views. Such a survey could provide a measure of the value placed on both aesthetic and energy-saving benefits.

REFERENCES

- Advertising Research Foundation. 1985. Focus Groups: Issues and Approaches. Advertising Research Foundation, Inc., New York.
- Greenbaum, T. L. 1988. The Practical Handbook and Guide to Focus Group Research. D. C. Heath and Company, Lexington, Massachusetts.
- Selkowitz, S. E., and J. W. Griffith. 1986. "Effective Daylighting in Buildings--Revisited." Lighting Design & Application, pp. 34-47.
- Southern California Edison. 1986. Daylighting: Performance & Design.
- Yellott, J. I. 1987. "Daylighting." Heating/Piping/Air-Conditioning, April, pp. 61-69.

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